MACHINERY

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THE MOVING PICTURE IN THE MACHINE TOOL BUSINESS*

BY CHESTER L. LUCAS†

Fig. 1. Section of Film illustrating Lathe Operation

The moving picture as an entertainer is rapidly making room for the moving picture as an instructor. This has been much in evidence recently in the scientific films which have been shown to illustrate plant life, biology, laws of physics and similar subjects. Another phase of moving picture activities was manifested in motion study for "scientific management" and a still later one in the moving picture as an aid to the machine tool builder in handling factory problems and selling campaigns. Several examples of the use of moving pictures in aiding the salesman will be cited in this article and suggestions offered whereby the application of the moving picture may be made of greater value in the machine tool industry.

Primarily, the service which the moving picture can render to the machine builder is instruction in the factory or the selling field. Suppose, for instance, a manufacturer of an intricate machine had trouble in getting his machines properly set up and started after they had been taken down at the factory for shipment to distant points. Although drawings and printed instructions were sent with each machine, there was often difficulty in setting up and starting. This manufacturer could have a moving picture film made to show just how the machine should be assembled and operated. It could show the sequence in which the members should be put together, graphically illustrate the important parts to be most carefully assembled, and in fact show the building up of the machine from the time it left the crate to the completed stage ready for operation. No amount of verbal or written instruction could make this process as clear as a picture could, and, moreover, the entire process of assembling the machine, unless extraordinarily long, could be carried through in a thousand feet of film, requiring about twenty minutes to show. The question will be raised as to how the man who is to set up the machine is to see the film in a case like this. If the machine is going to a point not far distant, the machine manufacturer can arrange to have the men who are to set it up come to his factory and see the film on a screen and listen at the same time to instructions. It would often be the case, however, that the film would be most valuable when the machine is going so far away that verbal instruction in the factory is impracticable. In such cases the erectors can have the film shown in the nearest moving picture theater in the morning hours and study it at leisure. It seems a safe prediction, however, to say that not many years will elapse before a small moving picture machine will be as essential a part of a manufacturing plant's equipment as the camera is at the present time. Many colleges and schools are now using moving picture machines for instruction purposes.

Depicting mechanical movements is an interesting field for the moving picture. It is practicable to slow down or speed up any movement when making a moving picture film. Suppose, for instance, the operation of a very slowly moving piece of mechanism is to be shown. In this case the moving picture camera is set up and the operating crank is turned very slowly so as to take as few pictures as possible and still show continuous movement. This is the method employed in making botanical pictures showing the growth of a plant—a process normally requiring several weeks being reproduced in a few minutes. To get this effect, the photographs are taken at the rate of one every eight hours instead of sixteen every second as for ordinary moving pictures.

The value of this possibility to the mechanical public is illustrated in an automatic machine that was made in Brooklyn, N. Y. This machine made one revolution every thirty-one

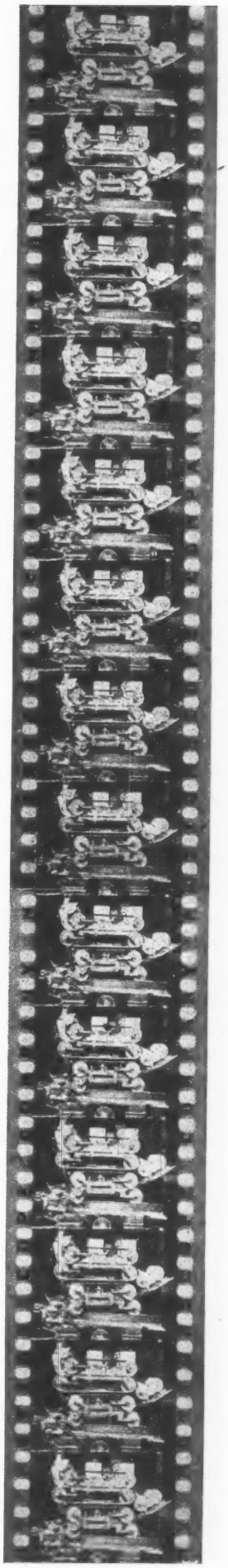

Fig. 2. Section of Film showing Operation of Automatic Machine

* For additional information on the moving picture machine and its relation to the machine shop see "The Moving Picture as an Aid to Mechanical Instruction," MACHINERY, May, 1912, engineering edition, and articles there referred to.

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minutes, and as it was desired to show its operation, a moving picture was made, taking the pictures so slowly that the full revolution of the machine could be thrown on the screen in a few minutes. Conversely, a mechanism operating at high speed may be taken by accelerating the picture-taking camera speed if it is desired to show it operating at a slower speed. Then when the film is projected at the normal rate of sixteen pictures per second, the speed can be made apparently slow. Thus the movement of any kind of mechanism can be graphically illustrated to students or apprentices, who perhaps could not grasp the operation if it were running at full speed. Especially is this true of spring-actuated mechanism, such as that employed in some adding machines in which analysis of the movements of the parts is difficult. The National Cash Register Co. uses moving pictures to instruct repair men as well as salesmen in the manipulation of the different parts of the mechanism.

In the comparatively slowly operated pictures the water takes on the appearance of molasses, and its motion seems sluggish in comparison with the rotation of the ball. The experiment has been carried still further by shooting the column of water with a rifle bullet. When this is shown on the screen, the effect of the bullet is to shatter the column from top to bottom, after which it is seen to pull itself together and finally return to the former position.

Another case where the moving picture will undoubtedly prove of value as an instructor is in showing the operation of automatic machinery that has been built and shipped perhaps years before. A concern building automatic machinery might have produced a machine such as that illustrated by the film from which the print in Fig. 2 was made, the mechanism of which was especially complex. Suppose, after the machine had been built for several years, it was destroyed by fire. If a film showing the operation of this machine was at hand, it should facilitate the building of a duplicate machine by a new set of men, for even though drawings are accessible, there is often doubt about operating points that a moving picture would clear up.

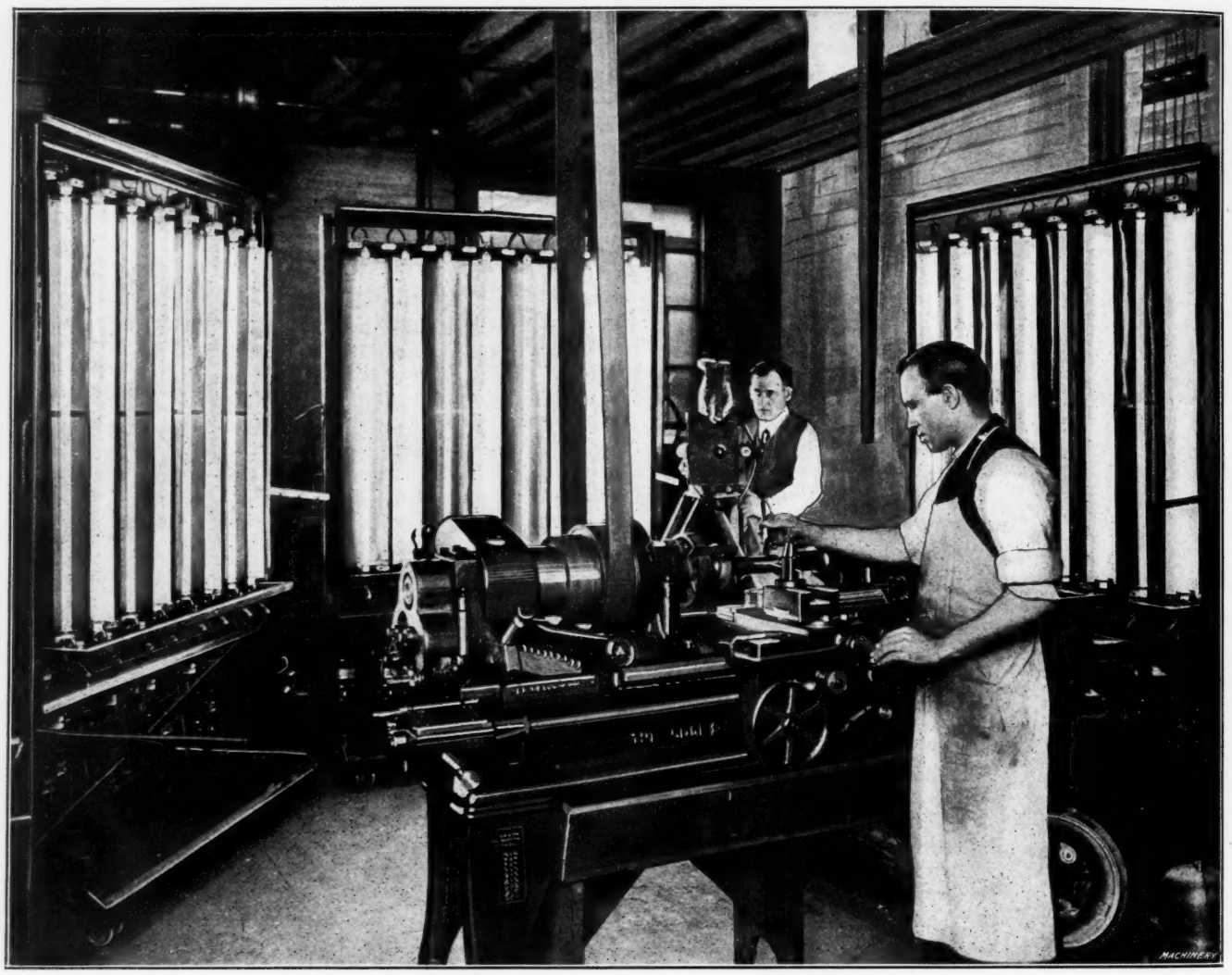

Fig. 3. Making a Moving Picture Film in a Machine Shop

Films for instruction purposes along mechanical lines can be used at much less expense than that of keeping and operating the mechanism itself. Thomas A. Edison proposes to demonstrate the elementary laws of physics to school children who would have great difficulty in understanding them from textbook descriptions, by making moving pictures of pumps having glass working parts. If the operating parts of any mechanism are inaccessible to observe or study, they are the parts that should be most clearly shown. Moving pictures of such sections make the operation of the machine clearly understood.

An instance of the aid of the moving picture to the scientist and teacher in the study of gyroscopic motion may well be cited. Why does a hollow rubber ball balance itself so perfectly at the top of a jet of water? By making moving pictures at high speed and projecting them upon the screen, the ball is shown to acquire a gyroscopic motion at the top of the column of water, tending to keep it from going off at the side.

Recent Developments in High-speed Pictures

Pathe Freres are undoubtedly among the leaders in producing scientific films, and it is through their courtesy that much of this information and some of the views were obtained. They have recently developed a high frequency spark apparatus used for taking pictures of rapidly moving objects. These pictures, of course, must be taken in a dark room; the film operates continuously, that is, without the intermittent motion of the ordinary moving picture camera. The spark operates at the rate of 1200 flashes per second and this number of exposures is made on the film. By this method, they have been able to record the path of a bullet shot at a clay pipe. By projecting the film at a normal speed, the bullet could be followed slowly across the screen until it entered the clay

pipe bowl. It seemed to remain within the bowl for a few seconds and then slowly, very slowly, the bowl dropped to pieces and the sections fell to the floor. Of course this film looked unnatural, but it showed the possibility of analyzing the action of rapidly moving objects.

Of course, there is hardly any need of mentioning the value of the moving picture as an aid in instructing apprentices and unskilled workmen in their duties. One does not have to draw on the imagination to a great extent to see the advantage of the moving pictures in instructing the apprentice as to the sequence of operations to follow in performing a given operation in the approved manner.

The Moving Picture as an Aid to the Salesman

Just as the highest type of technical advertising involves showing machine tools actually at work, so the great advantage of the moving picture lies in its ability to show to the prospective customer just what the advantages of the machine in operation are. A large steel company was particularly interested in securing foreign business. It wished to show foreign prospects the equipment of the plant, the large lathes, planers and the magnitude with which the business was conducted. It was impossible to bring these men to the works, so the company decided to take the works to the men. Accordingly, moving picture films were made, showing panoramic views through the plant and detail views of some of the large machine operations. These films were sent to the company's foreign agents, who, through the aid of a projecting machine, showed them to the prospective customers. The views made such an impression that large orders from these foreign countries were soon received.

The educational film showing, for instance, the making of a typewriter or the building of an automobile is becoming quite common, and its value as an advertising attraction has been well demonstrated. Several large manufacturing companies are already exhibiting films at conventions and exhibitions showing the manufacture of their product.

Small portable projecting machines are coming to the front more rapidly than ever. One of the latest of these weighs but little more than a typewriter, and the turning of the crank also operates a magneto, thus generating electric light for illuminating the pictures. The machine is self-contained and, with its case, comprises a portable outfit which a salesman can easily take into the office of a prospective customer. Then, by drawing the shades, the moving pictures can be projected upon the blank wall to show the superintendent or manager just how the machine works. Of course, films would be selected to exploit some impressive job, showing the machine working at its full capacity, preferably on the class of work done by the prospect. The salesman can demonstrate exactly how the different movements are secured. The explanation of an automatic feed throw-off, or the action of a cam movement, could be readily made in a demonstration of this sort.

Many times a salesman would like to take a prospective customer to a plant to show one of his firm's machines in action. This is sometimes difficult to accomplish; days when the machine would be working at its best are comparatively few. Even should a time be arranged for showing the prospect the machine at work, the surrounding conditions might detract from the effectiveness of the demonstration, and if the shop were far away from the prospective customer's location, he might be unwilling to go there. With a good film of his machine to show, however, a salesman could take his prospect, or several of them, to the nearest moving picture theater, and for a small sum the proprietor would be glad to run the film for him during the morning hours. There is scarcely a town of 500 inhabitants or more but what has its moving picture theater, and there is hardly one of the managers who would not gladly run special films during hours when the theater would otherwise be idle. Similarly, the morning hours of a theater could be utilized for instructing the apprentices of nearby factories.

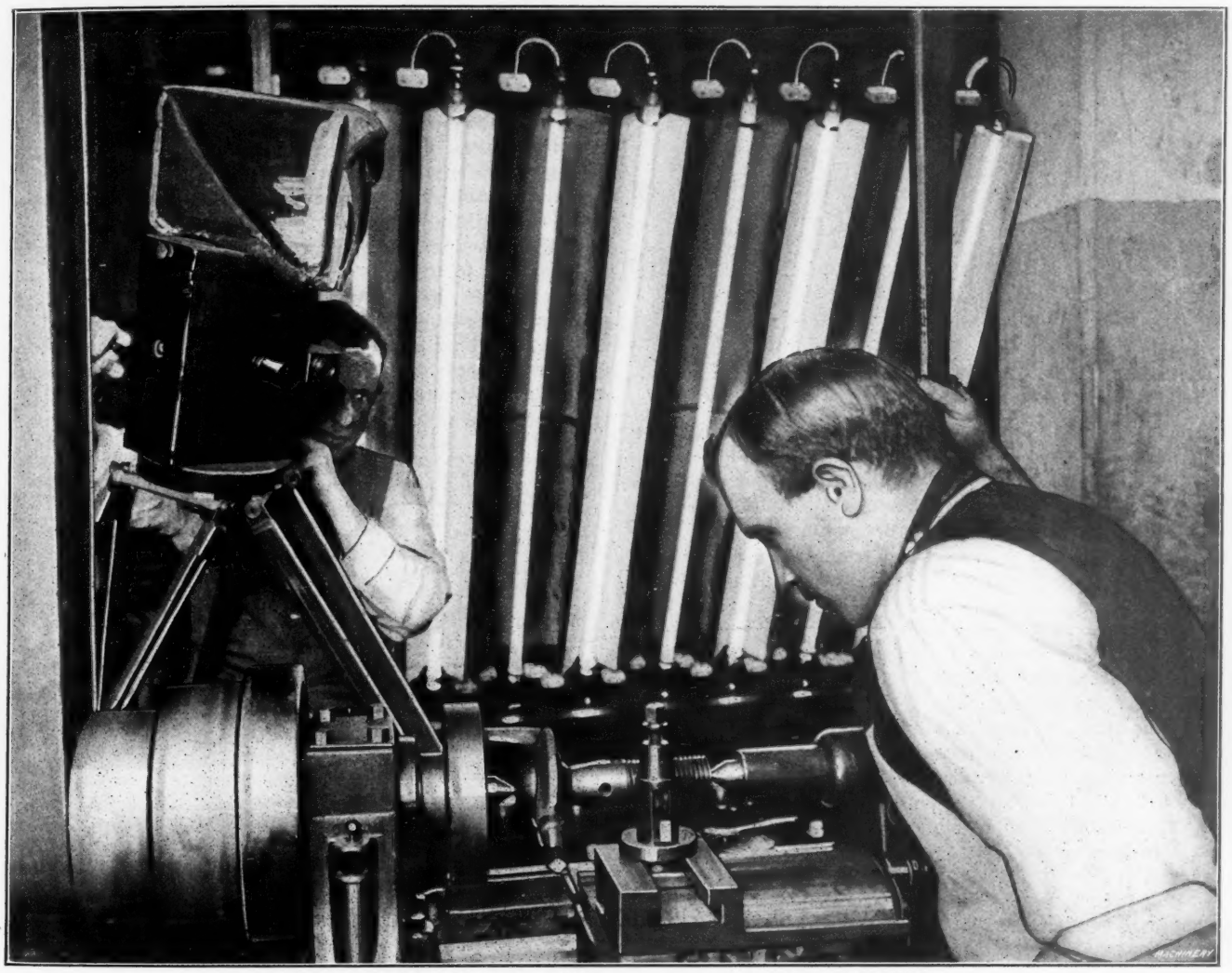

Fig. 4. The Way the Camera and Lamps are arranged to make a Detail Film

The Motionscope Co., of Indianapolis, Ind., makes a port-

able outfit by means of which a salesman can show his prospect the film in his own factory or even in the salesman's room at the hotel. This machine is illustrated in Fig. 5, and is adjustable for any electric light current whether alternating or direct, 110 or 220 volts. Less than five minutes is required to put it in operation and it will show a picture as large as six feet wide. This machine may also be used for showing slides or stereoptican views. Equipped with a 24-inch screen, the outfit is contained in a case measuring 24 by 14 by 9 inches, and weighs approximately 35 pounds. Fig. 6 shows the way in which the machine is used in an office. The operation of any machine tool can be demonstrated with such an outfit. The salesman can stop at any point and dwell upon particular features that the view shows and he is not at the disadvantage of putting forth his argument in the midst of a noisy shop where much of his selling powers would be wasted. The film, of course, would show the machine working at its best, for moving pictures are not made on the "off days" of the machine.

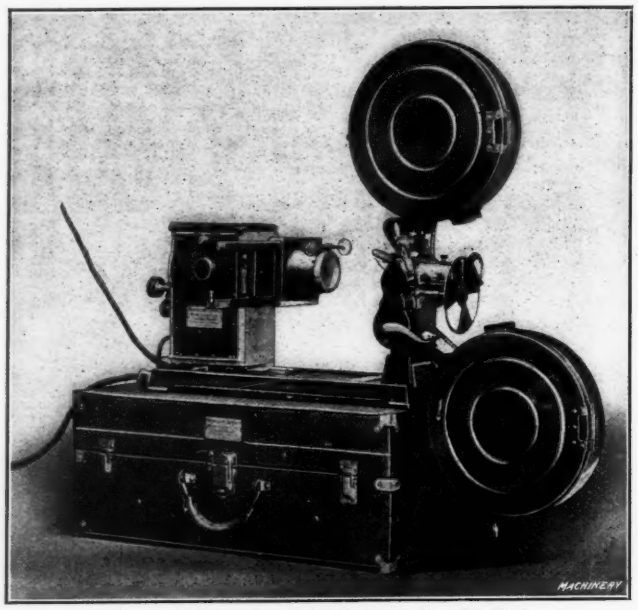

Fig. 5. Salesman's Portable Projecting Machine

In instances where it would be impracticable to send a salesman because of the distance, a film could be sent by registered mail to a prospective customer a thousand miles away. Arrangements could be made with a local moving picture house to show the film, this perhaps making the closing argument in a chain of selling correspondence.

The cost of making a mechanical moving picture film of one thousand feet or more in length is about one dollar per foot. This includes the services of the men who go to the plant, arrange the lighting and apparatus and make the film. When this film is once made, however, copies can be made at the cost of fifteen cents a foot. Should a sales manager decide to equip six of his salesmen with projecting machines and films to show a machine tool, it could be done at the rate of about thirty cents per foot, figuring the cost of the first film at one dollar per foot and the additional five at fifteen cents per foot.

Making a Mechanical Moving Picture Film

The requirements for making a moving picture film of a machine tool operation are comparatively simple. The film manufacturer understands how to get proper exhibition effects of any class of mechanism, and the lighting requirements are easily taken care of. It is seldom that a machine tool operation can be photographed without the aid of artificial light. Cooper-Hewitt electric lights are used to a large extent by the moving picture film men, and by using enough of these lights in conjunction with arc lamps it is possible to take views.

In order to show the exact method in which a mechanical moving picture of a machine tool operation is made, the views in Figs. 3 and 4 are reproduced. This shows the method of procedure in making a picture to demonstrate the operation of cutting a thread upon a jack screw. The lathe used was not equipped with a thread-cutting attachment as it was desired to have the operation explained on the ordinary type of lathe.

The lathe is shown set up for a thread-cutting operation, and as the object of the part of the film being made in Fig. 3 is to secure a general effect, showing the position of the operator and the manipulation of the lathe, the moving picture camera is situated at the back of the lathe. Cooper-Hewitt lamps are used, there being in this case three banks, each of which has eight tubes having 800 candlepower each; thus in each bank there is 6400 candlepower or a total of 19,200 candlepower in all. The positions of the banks of light upon the standards may be changed at will by raising, lowering or tilting. All being in readiness, the machine tool is operated in a natural manner, and the camera man turns his film at the rate of sixty turns per minute, making exposures at the rate of sixteen per second. Those exposures, of course, show the operator and machine in ever-changing positions, each of which represents conditions at intervals of 1/16 second; thus the fifteen views shown in the strip of film in Fig. 1 represent the 15/16 second time required for the lathe man to drop his hand from the shipper rod down to the cross-feed screw on the carriage.

To make the thread-cutting film complete, a section would necessarily show the selection of the change gears and method of setting up the work. The setting in of the cross-slide after the successive cuts could also be graphically shown. In fact, a film for teaching such an operation should show enlarged views of all of the important phases of the work. In making such detail sections of a moving picture, the camera is set up as illustrated in Fig. 4. In this view, but one bank of lights is required, raising and inclining it so the rays will fall directly upon the work. The camera has also been raised and is pointed down upon the top of the screw thread and tool so as to show the actual cutting operation, the form of chip turned off, and the comparative speed of the work. The object of this feature of the film is to show the reversing operation necessary at the end of the thread. The thread tool is nearing the end of the cut and the operator, with his hand upon the shipper, is about to reverse the traverse of the carriage. This section of the film would be particularly valuable in instructing the novice in properly withdrawing the tool and reversing the lathe at the end of a thread cut.

Fig. 6. Demonstrating a Machine Tool in a Prospect's Office

Credit is due Pathe Freres, Jersey City, N. J., and the Harold Ives Co., 1 Madison Square, New York City, makers of industrial films, for assistance in preparing this article.

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October 13 was celebrated in New York City by flights from Staten Island around Manhattan Island. The celebration commemorated the first flight with a motor-driven aeroplane by Wilbur Wright at Kittyhawk, N. C., October 13, 1903.

MACHINING CONVEX AND CONCAVE SURFACES

DESIGN OF CONVEX AND CONCAVE TURNING ATTACHMENTS FOR USE IN THE LATHE AND VERTICAL BORING MILL

BY ALBERT A. DOWD*

The machining of convex and concave surfaces is a problem which frequently confronts the manufacturer, and its solution may be required under a great variety of conditions. Even the size of the work to be machined is a controlling factor, as it determines to a certain extent, the type of machine to be used. For example, the small steel cup washer shown in the upper part of Fig. 1 would naturally be machined on an engine lathe or turret lathe of the horizontal type, while the huge ball pipe joint in the lower part of the illustration would preferably be handled on some type of vertical boring machine. A manufacturing proposition may be necessary where one thousand or more pieces are to be handled, or it may be that only one piece is required. The work may be concave, or convex, in a plane perpendicular to the center of rotation, or it may be parallel with it and either internal or external. As the conditions governing the handling of work of this nature are so varied, and as the pieces themselves are of such widely different forms, it is very evident that we must consider several types of machines to which the forming devices may be attached. The construction of these devices must be adapted to the class of machine on which they are to be used, and this naturally influences the design of the attachments. The reader's attention is called to a few important points along these lines.

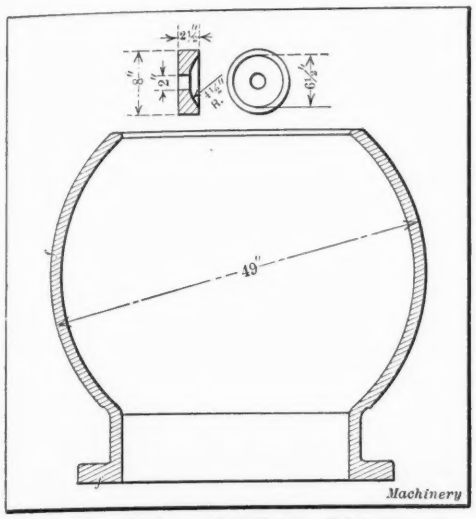

Fig. 1. Cup Washer and Ball Pipe Joint—Examples of Concave and Convex Turning

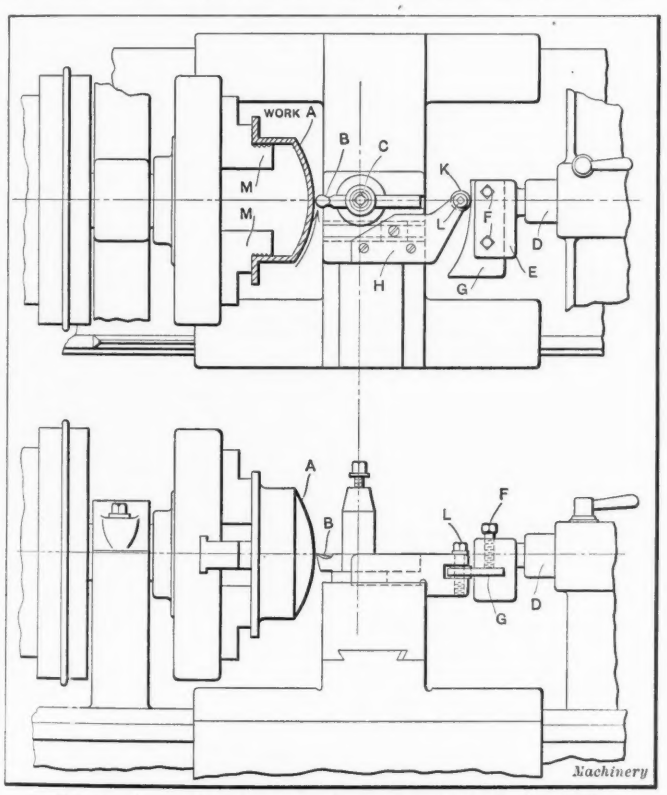

Fig. 2. Simple Attachment for Convex Turning in Engine Lathe

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Important Points in Design

1. Whenever possible the attachment should be so designed that the form will be generated radially, so that the same portion of the tool will do the cutting at all times.

2. Try to use stock sizes of steel for the cutting tools so that replacements can be made easily.

3. See that the tool does not overhang too much, and that it is well supported and rigidly held. Care should also be taken that moving portions of the tool-holder or slide are of generous proportions and possess means of adjustment for wear.

4. Generate the curve by means of the machine alone, whenever possible, so that errors in the contour may not be occasioned by the failure of the operator to keep a certain roll or stud in contact with the forming plate.

5. When the attachment is of the type requiring the use of a roll and forming plate, it is essential to so arrange the plate that it will act as a guard against the tool being forced away from the work. That is, the action of the roll against the plate should be in the direction tending to carry the tool into the work, so that the thrust of the cut will always assist in keeping a positive contact between the roll and the plate. Counterweights or springs should also be used to obviate any tendency to draw in.

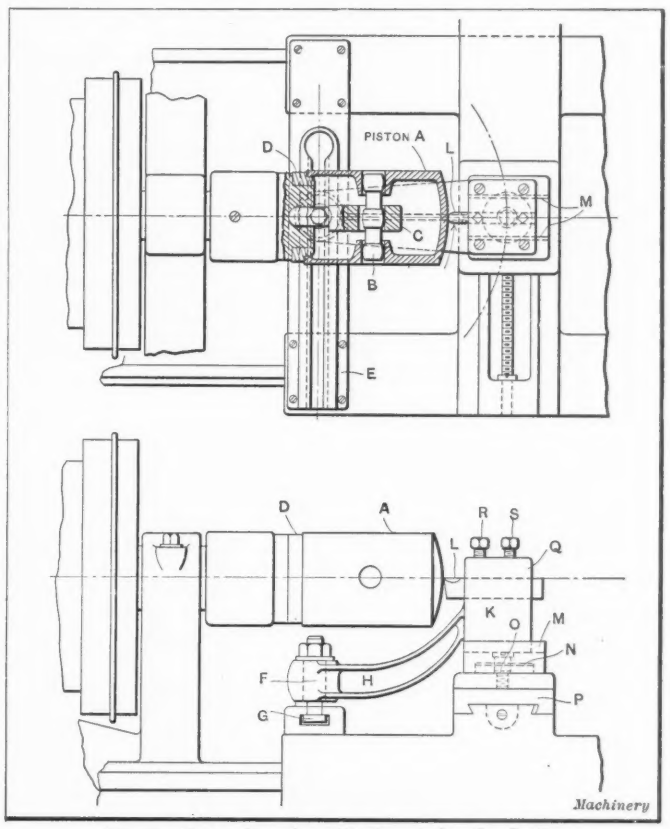

Fig. 3. Piston Crowning Attachment for the Lathe

6. Economy in operating expense and the first cost of the attachment should also be considered, while the difference in workmen's rating is also a factor which should not be overlooked.

Radius Turning on the Engine Lathe

When concave or convex turning or boring is required on only one or two pieces, or, in cases where it is not practicable to combine the radial work with other operations, the engine lathe may be adapted to a great variety of conditions. In manufacturing, it may occasionally be used to advantage, especially in cases when the length of time required to do work is sufficient to permit one man to run two machines.

Fig. 2 shows the simplest kind of a forming attachment for convex work, which is adapted to the engine lathe. The work *A* is held by the inside in the chuck jaws *M*. The bracket *H*

is screwed to the top of the cross-slide and carries at its outer end, the tool-steel hardened and ground roller *K*, held in place by the screw *L*. The tailstock spindle *D* receives the holder *E* in which the plate *G* is inserted and secured by the two screws *F*. This plate is formed to the proper radius and is of tool steel unhardened. The cutting tool *B* is held in place in the regular toolpost *C*. The form of the cutting end of this tool is important as it must be formed to a perfect radius, in order that the cutting action may be uniform. In operating this attachment, the cross feed-screw is thrown into engagement, and the operator is required to force the roll *K* against the forming plate by means of the handwheel controlling the longitudinal feed of the carriage. An attachment of this sort requires the entire attention of the operator and, therefore, variations are liable to occur in the contour of the work, due to imperfect contact between the roll and plate; hence it is a very poor attachment to use if there are many pieces to be machined.

Piston Crowning Attachment for the Lathe

The arrangement shown in Fig. 3 was used for manufacturing in large quantities, and four lathes were equipped in this manner and required the services of two men to operate them. The piston *A* was located on a special draw-back chuck, on the steel locating ring *D*, and was drawn back firmly by the rod *C* acting on the pin *B* through the wrist-pin holes. A cast-iron bracket *E* is bolted onto the carriage of the lathe and is slotted at *G*. A cast-steel bracket *H* terminates at its upper end in the tool-block *K* which is dovetailed at *M* as shown in the plan view. The stud *F* is tee-shaped at its lower end to fit the slot in the bracket *E*. A steel block is screwed to the top of the cross-slide *P*, and is shouldered at *N* to fit the upper block in which the dovetailed tool-block *K* slides. The screw *O* simply holds the units together. A steel plate *Q* contains the two screws *R* and *S* which securely hold the tool *L*. In operating this device, the cross feed-screw is simply thrown into engagement and its forward action causes the tool to swing radially at the desired distance from the center *F*, thus developing a spherical surface. This device was comparatively inexpensive and the results obtained by its use were very satisfactory.

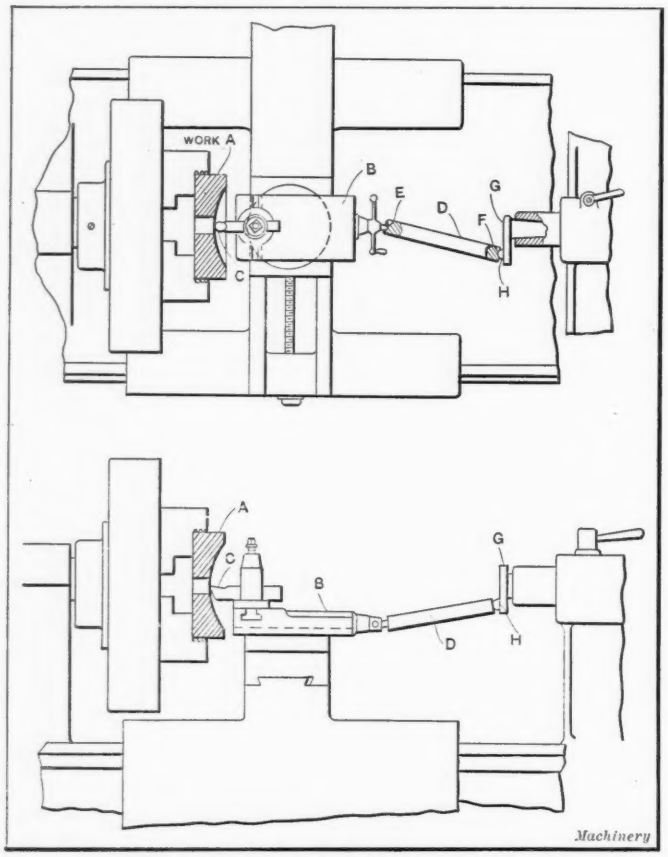

Fig. 4. Concave Turning with Compound Rest

Concave Turning with a Compound Rest

A very simple device which may be used when one or two pieces only are required is shown in Fig. 4, but the radius which can be generated by this method is limited by the size of the compound rest. The work *A* is held by the outside in chuck jaws, and the tool *C* generates a radius equal to the distance from the end of the tool to the center of the swivel. The socket *G* is placed in the tailstock spindle and the overhanging end contains the round head pin *H*. The bar *D* is cup-shaped at *E* and *F* and bears against the end of the compound rest screw at *E*, while the other end engages the button at *F*. In using this arrangement, the holding-down gibs or straps of the compound rest swivel, are set up to produce considerable friction, and the tailstock spindle is fed forward by hand, thus causing the compound rest to swing on its own center, thereby generating the desired radius. It is obvious that the carriage gibs must be tightened to prevent any longitudinal movement.

Radius-bar for Concave Turning

A very simple arrangement for the engine lathe is shown in Fig. 5. The work *A* is held by the outside in chuck jaws and the round nose tool *B* is used to generate the concave surface. The tool is held in the ordinary manner in the toolpost *C* on the cross-slide of the lathe. A slotted holder *K* is tapered on its rear end to fit the tailstock spindle *L* and is slotted to receive the flat steel radius-bar *G* which is held in position by means of the shoulder screw *H*. The stud *F* enters the tool slot of the cross-slide and serves as a pivot for the forward end of the radius-bar. This bar is made of the correct length to generate the desired radius. As in a previous instance, the cutting end of the tool *B* must be ground to a perfect radius. The arrangement shown here is a very simple one and may be used for various pieces of work by the substitution of a bar of the proper radius.

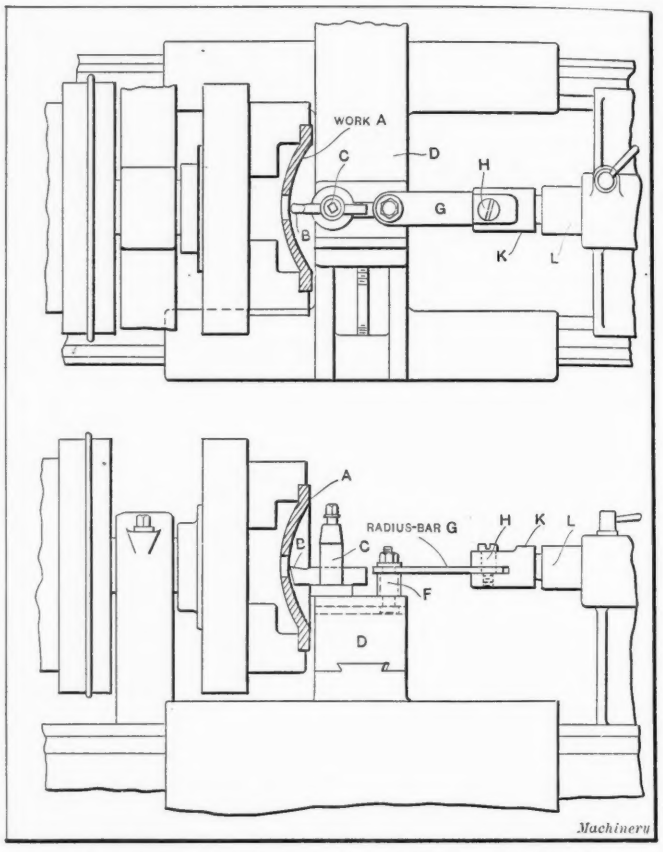

Fig. 5. Radius-bar Type of Concave Turning Attachment

Pulley Crowning Attachment for the Engine Lathe

Fig. 6 illustrates an arrangement that was applied to an old-style Pratt & Whitney lathe which had, at one time, been equipped with a taper attachment. The arrangement shown was specially designed for crowning pulleys which previously had been "chucked," faced and rough-turned straight on the periphery. A keyway had also been cut through the hub. A special arbor *D* was held on centers in a lathe, the dog *E* acting as a driver in the special faceplate *F*. The pulleys were put on the arbor until the face of the hub came up against the shoulder *H*, the spacer *J* being interposed between the two hubs. The cast-iron driving plate *K* was then put on,

followed by the washer *M*. The nut *L* was then used to tighten the pieces in position. The driving bar *G* was used in order to prevent vibration which would otherwise be troublesome due to the thin flange of the pulleys. The two round-nosed tools *B* were mounted on the tool-slide *C* and held in the ordinary manner. A steel plate *Y* was bolted to the end of the slide and overhung sufficiently to permit the bar *X* to pass through it. This bar passed completely through the carriage and was a sliding fit in it. The stud *Q* passed through the bar and formed a bearing for the roller *R*. The cast-iron bracket *N* was fastened to the rear of the carriage and was tapped at its outer end to receive the screw *O*, which was used for adjusting the compression of the spring *P*. This spring was of square section ¼ inch in size and served to keep the roll in contact with the cam-plate *S*. Two brackets *V* and the plate *U* were a part of the taper attachment with which the lathe was originally equipped. The dovetail plate *T* served as an adjustable support for the cam-plate *S* and it was held in its proper location by the screws *W*. The upper view in the illustration is partially broken away to show the roll *R* in position

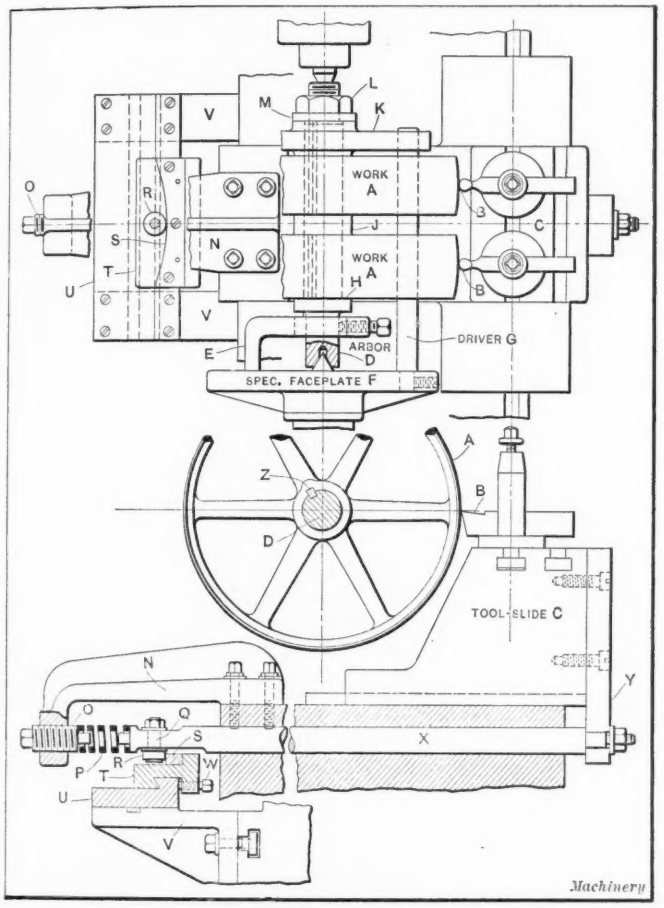

Fig. 6. Pulley Crowning Attachment for Engine Lathe

against the cam-plate. The operation of this attachment is obvious and it is only necessary to state that its action was very satisfactory.

Convex Turning Attachment using a Radius-bar

Fig. 7 shows a rather peculiar attachment for turning the convex surface on the cast-iron head-piece shown at *A*. The device is applied to the engine lathe, and its construction is such, that by the substitution of various lengths of radius-rods, it may be used for an infinite number of radii. The cutting tool *B* is held in the toolpost *C* in the ordinary manner and the longitudinal feed-screw is left free so that the carriage *R* may be perfectly independent. The bracket *F* is secured to the inner ways of the lathe so that it is absolutely prevented from moving. This bracket is dovetailed along its upper face and the slide *G* is mounted upon it. A tool-steel stud *E* is screwed into the side of the cross-slide and enters the bushing *H* which is contained in the bracket slide *G*. This bushing is eccentric and is split along one side thus permitting a slight adjustment to compensate for wear. The binding screw *J* holds it rigidly after setting. The tie-rod *L* connects the carriage *R* with a special bracket *Q* at the rear end of the lathe, this bracket taking the place of the regular tailstock, and being gibbed to the ways in such a manner that it is free to slide longitudinally. The tie-rod is held in place by the

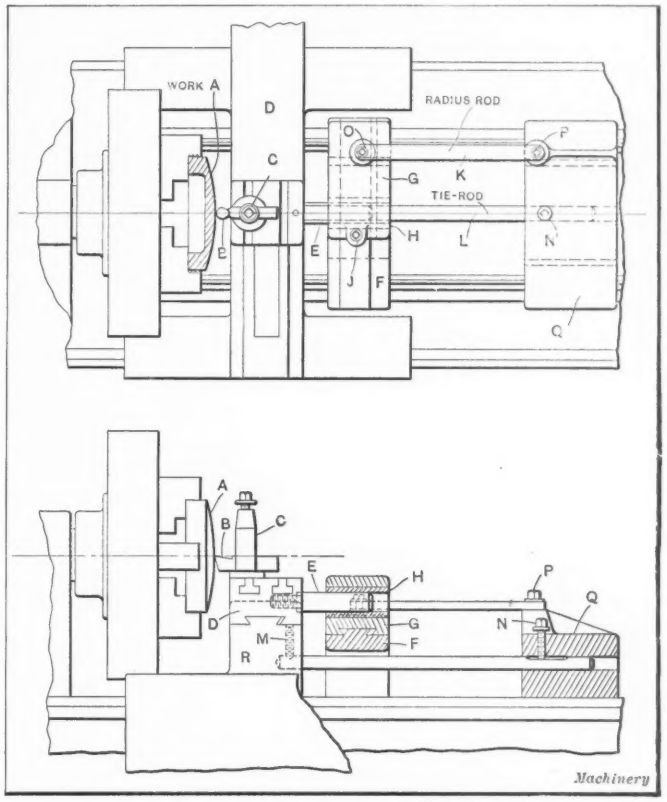

Fig. 7. Convex Turning Attachment of Radius-bar Type

screws *N* and *M*. The radius-rod *K* is made from a piece of flat steel and swings on the two screws *O* and *P*, located in the bracket slide and the tailstock substitute respectively. In the operation of this mechanism, the cross feed-screw is thrown

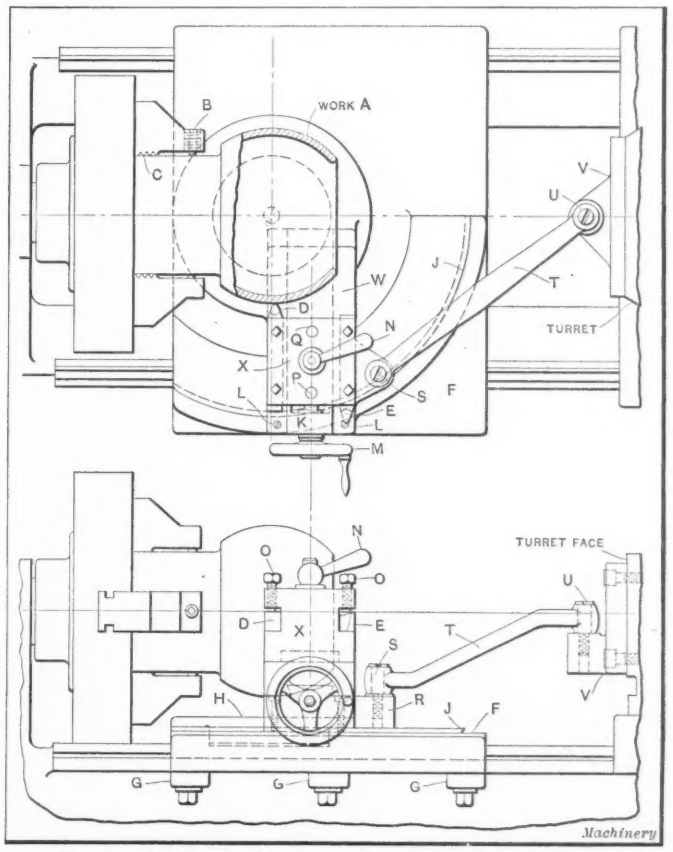

Fig. 8. Spherical Turning Device for Horizontal Turret Lathe

into mesh and the slide *D* moves forward carrying with it the bracket slide *G* to which the radius-rod is attached. As the bracket *F* cannot move longitudinally, it is evident that the tail-

stock substitute *Q* will be forced backward by the radius-rod and will carry with it the entire carriage and cross-slide, thereby generating the desired radius.

Ball Turning Device for the Horizontal Turret Lathe

We now come to a somewhat more pretentious device designed for the horizontal turret lathe for the purpose of generating the spherical portion of the steel pipe joint shown at *A* in Fig. 8. This work is held in chuck jaws at *C*, the supplementary screws *B* being used in the outer ends of the jaws to assist in supporting the work. The regular turret lathe cross-slide and carriage are removed and the special slide *F* is substituted. It is gibbed firmly to the ways in the desired position by the gibs *G*. Directly under the center line of the spindle, a large circular recess is bored to receive the swivel *H*, and circular rim *J* is dovetailed so that the outer end of the swivel may be gibbed at *K* to insure rigidity. The two screws *L* hold the gib. The slide *W* is dovetailed and has an adjustment for diameters, controlled by the handwheel *M*. The roughing and finishing tools *D* and *E* are held in the indexing toolpost *X*, the tools being secured by the screws *O*. The index location is insured by means of the pin *P* entering a hole directly underneath it in the slide, and the other index position is determined by the hole *Q*. The binder *N* locks it rigidly. At the right of the swivel the lug *R* is built out to receive the pivot screw *S*, on which the forward end of the radius-arm *T* is fastened. A bracket *V* is bolted to the face of the turret and carries the screw *U* which supports the other end of the radius-arm.

In the operation of this device, the turret longitudinal feed is used while the roughing tool *D* removes the scale from the casting. The toolpost is then indexed and the finishing tool *E* completes the work. This attachment gave very good results

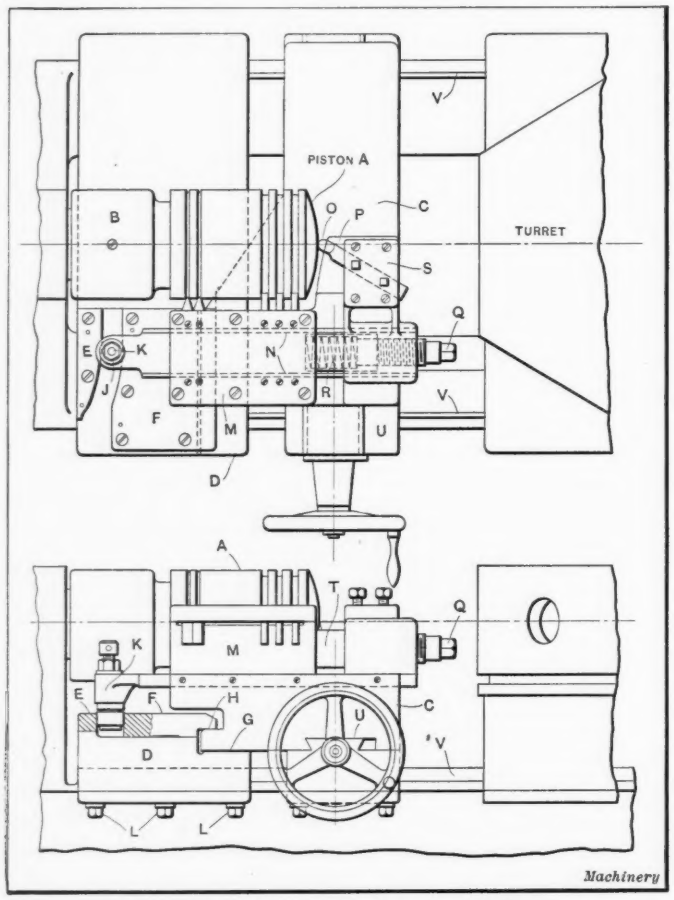

Fig. 9. Turret Lathe Piston Crowning Attachment

and was satisfactory in every respect. There are several points in the construction of this device to which attention should be directed. One of the points is the turret toolpost by means of which the tools always remain set, so that the diameters are easily held to size. Another point is the dovetail gibbing of the outer portion of the swivel. This method does away with all possibility of chatter, providing the gib is kept tight. Another advantage is the adjustment for various diameters by means of the slide *W* which is mounted on the swivel.

Turret Lathe Attachment for Crowning a Piston Head

The attachment in Fig. 9 is part of an equipment of tools for finishing the piston *A*, the work being held by the inside on a special chuck *B*, which is screwed onto the end of the spindle. There are turning tools fastened to the turret which are in action simultaneously with the attachment shown. These are not shown in the illustration, as they have nothing to do with the radius attachment. A special steel cross-slide *C* is mounted on the carriage in place of the regular slide, and

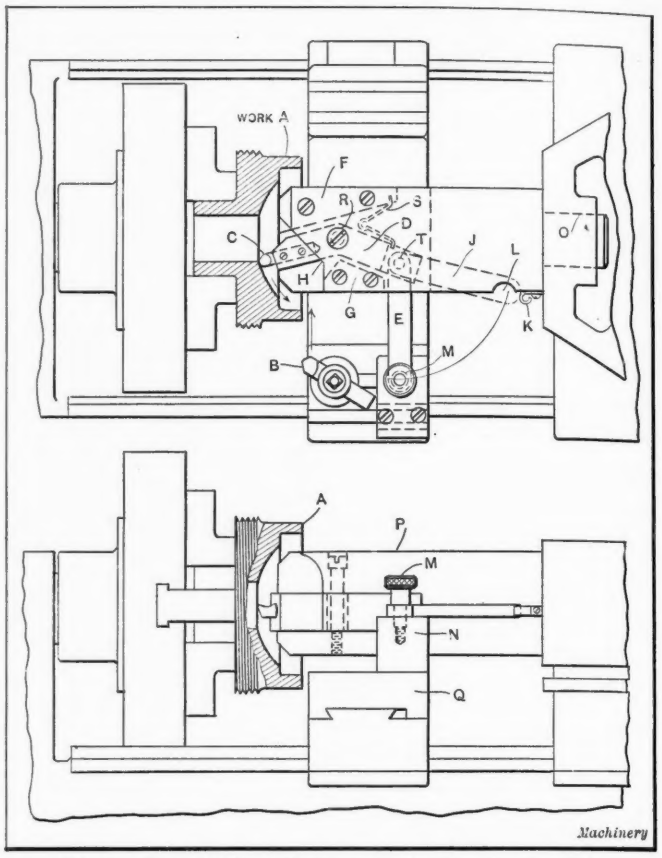

Fig. 10. Turret Lathe Attachment for turning Concave Seat

the overhanging portion *G* carries a tool-block *M* in which the grooving tools for the piston are mounted. A special bracket *D* is firmly gibbed to the ways and secured by the screws *L*. The tool-steel forming plates *E* and *F* are screwed to this bracket and doweled in position. The plate *F* also acts as a strap for the overhanging portion of the cross-slide at *H*. A hardened and ground tool-steel roller *J* is pivoted on the stud *K*, and controls the form of the crown by its contact with the plate *F*. The other plate *E* only acts as a guard. The radius forming slide is dovetailed at *N* and passes through under the tool-block. It carries a tool *O* mounted in the tool-holder *S*. A supporting pad *P* is provided on the cross-slide directly under the tool-holder and serves to prevent vibration. A heavy coil spring *R* is used to insure proper contact of the roll with the cam-plate. The necessary adjustment is obtained by means of the screw *Q*. A brass tube *T* protects the spring from chips and dirt which might otherwise impair its action.

This attachment was built for a large manufacturing plant in the East, and proved very satisfactory. It is designed so that all the tools can work at the same time. In building the attachment, it was found necessary to fit the dovetail slides and other moving portions, after the tool-blocks were put in place, and the tools clamped in position. This was unavoidable because of the clamping strains, as these caused a certain amount of distortion, making it necessary to do the fitting after the tool-blocks were in position.

Radius Boring Attachment for a Horizontal Turret Lathe

The device for generating the internal radial seat in the brass casting *A*, shown in Fig. 10, is somewhat out of the ordinary, and in addition to this, it is comparatively inexpensive. Furthermore, it is practically a self-contained unit, and requires no special fitting or attachments to the machine.

The steel bar *P* is held in the turret by the shank *O* and is

secured in place by the turret binder. The bar is slotted completely through to receive the swivel arm *D* which is a machinery steel forging ground on two sides to fit the slot. The forward end of this swivel arm carries the tool *C* which is set at the proper distance from the screw *R* to produce the desired radius. At the end of the bar, a mill cut is made at *H* in order to permit access to the screws which hold the tool in position. The steel filler blocks *F* and *G* are put in to give additional rigidity to the end of the bar. The flat spring *S* is simply used to prevent back-lash in the swivel arm. The operating link *E* enters a slot in the end of the swivel arm and is held by the pin *T*. A special steel block *N* is fastened to the cross-slide and the knurled screw-pin *M* couples the end

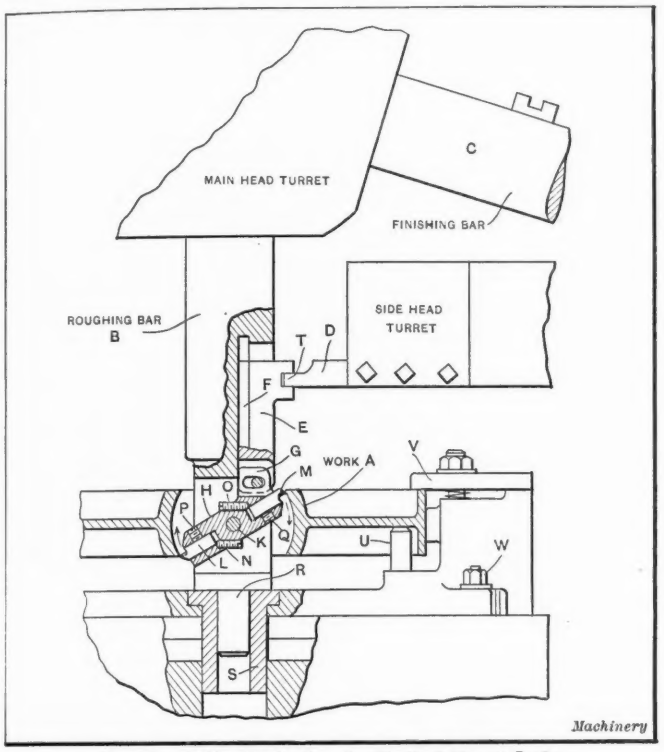

Fig. 11. Radius Boring-bar for Vertical Turret Lathe

of the link to the slide. The tool *B* is used in connection with the attachment for facing the end of the work.

In operation, the cross-slide feed-screw is engaged and the radius nicely generated by the radial action of the arm. As

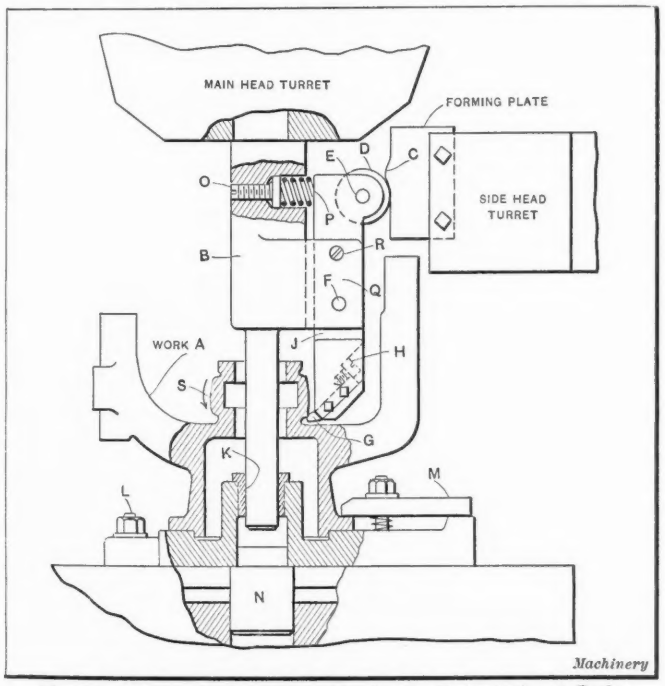

Fig. 12. Attachment for Convex Turning in Vertical Turret Lathe

soon as this operation has been completed, the knurled screw *M* is rapidly removed and the link *E*, swung over into the slot *J* where it is held by the flat spring *K*. The cut *L* allows the fingers to grasp the link when the radial attachment is again put into use. This attachment has many good points, the only serious draw-back being that there is a slight tendency to chatter when the cut is excessive.

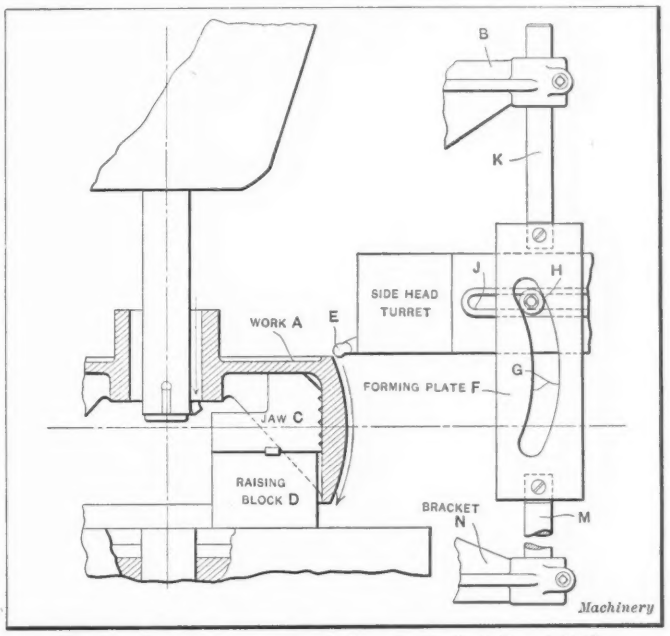

Fig. 13. Device for crowning Pulleys in Vertical Turret Lathe

Radius Boring-bar for the Vertical Turret Lathe

The device shown in Fig. 11 was designed for use on the vertical turret lathe, and was used in connection with other tools in the main and side heads for the purpose of boring the radial portions of the automobile crank-case cover bracket shown at *A* in the illustration. The work is held on a locating fixture upon three pins *U* and is clamped by means of the straps *V*. Only a part of the work is shown, as the piece is a

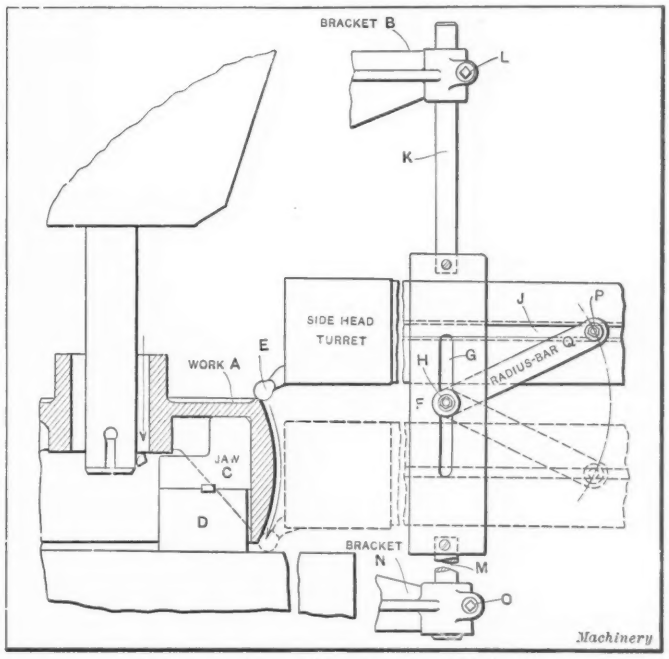

Fig. 14. Another Pulley Crowning Attachment

somewhat crooked one and the other portions have nothing to do with the radial boring. The fixture is held to the table by three tee-bolts *W* and it is centered by the steel bushing *S*, which also acts as a guide for the stem of the boring-bar *R*. This bar is slotted out at its lower end to receive the swivel block *H*, which carries the tools *L* and *M* for rough-boring the radius. The block swings on the pin *K*, when forced to do so by the downward action of the operating arm *E*. The two cutting tools are backed up and adjusted by means of the screws *N* and *O*, and they are held firmly in position by the set-screws *P* and *Q*. The bar *B* is slotted out to receive the tongue *F* on the operating arm, and the lower end of this arm contains a pin which works in a slot at *G* in the upper

portion of the swivel tool-block. The steel piece *D* is held in the side head turret and engages a groove in the upper part of the operating arm.

The finishing bar *C* is of the same general construction as the roughing bar except that only one tool is used for finishing, instead of the two shown in the roughing bar. It is well to note that the use of two tools in roughing practically reduces the roughing time one-half, it being only necessary to cut half way with each tool, as one comes up from the bottom while the other is coming down, so that the two cuts meet at the center. In operation, the down feed of the side-head turret is started, thus providing the necessary power for operating the device. This scheme gave very satisfactory results as far as accuracy is concerned, but as the mechanism was confined in a small space, the size of the tools could not be made large enough to properly conduct away the heat generated in boring.

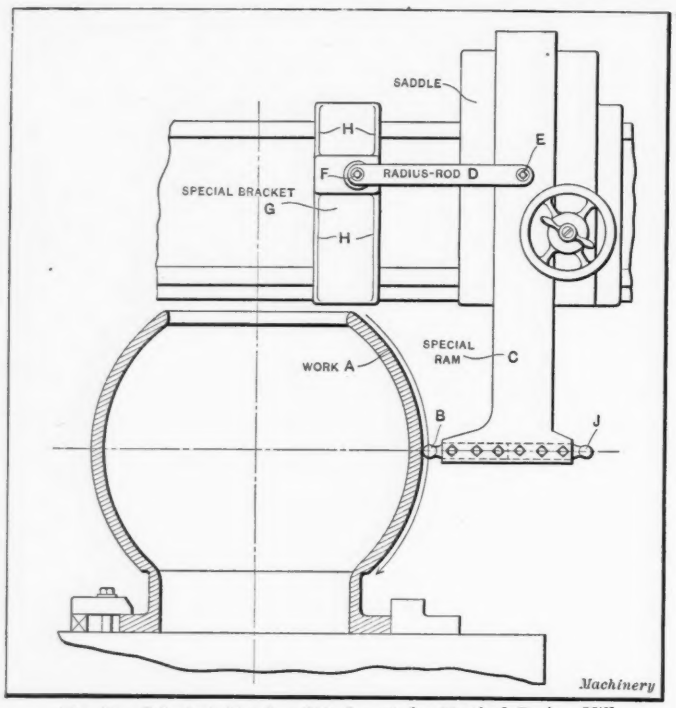

Fig. 15. Spherical Turning Attachment for Vertical Boring Mill

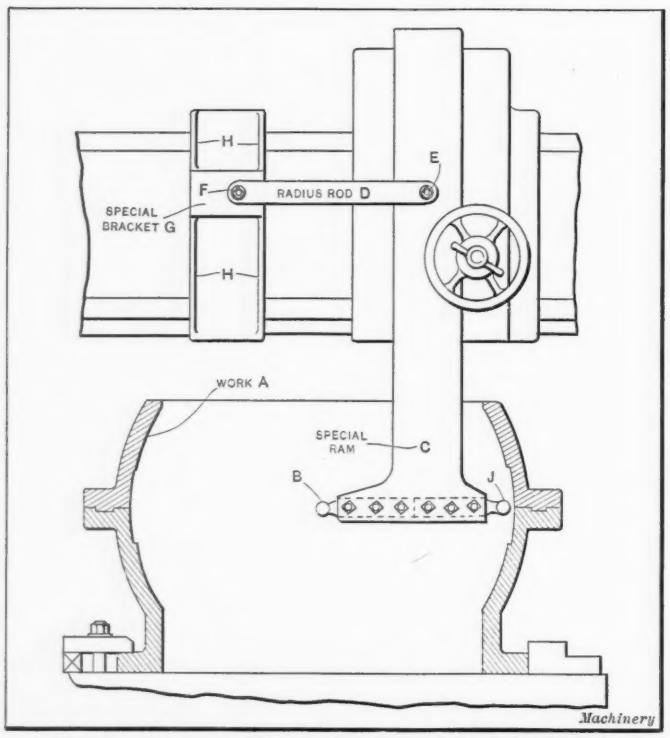

Fig. 16. Attachment shown in Fig. 15, used for Internal Work

Convex Turning Device for a Difficult Piece of Work

Fig. 12 shows a device for convex turning. The jack-shaft tube bracket *A* has been previously machined at its lower end and is located for this setting by the finished surfaces. A special fixture is bolted to the table of the vertical turret lathe, by the three tee-bolts *L*, and it is firmly secured by the straps *M*. The stud *N* serves to center the fixture on the table, while the bushing *K* acts as a guide for the end of the bar. The radial surface *S* is to be machined at this setting, and it will be noted that it is somewhat confined. The generating bar *B* is a 0.40 carbon steel forging, and the piloted end is carbonized, hardened and ground to a running fit in the bushing *K*. The projecting portion *Q* of the bar is of rectangular section and is slotted to receive the swinging arm *J*, which is pivoted on the pin *F*. This pin is equi-distant from the end of the cutting tool *G* and the center of the pin *E*. A hardened and ground tool-steel roller *D* revolves upon the latter, and is kept in contact with the forming plate *C* by means of the spring *P*, which is very stiff. Adjustment is provided through the screw *O*.

In operating this device, the turret down feed is used and the side-head turret is locked in the proper relation to the cutting tool, to produce the radius at the correct height on the casting. For the finishing cut, the roughing tool *G* is removed and a finishing tool substituted. A special screw *H*, having a large head against which the ends of the tools bear, makes this comparatively easy. The work can be turned closer to size if two roughing tools and a finisher are used, leaving only about 0.010 inch for the final cut. A defect in this fixture is that the thrust of the cut has a tendency to force the roll away from the cam-plate, and the action of the spring is sometimes insufficient to entirely overcome this. Had it been possible to design this attachment in such a way that the thrust of the cut would simply hold the roll more firmly against the forming plate, its action would have been more positive. The results obtained were sufficiently close, however, to conform to the required limits of accuracy, and it may therefore be stated that its work was satisfactory.

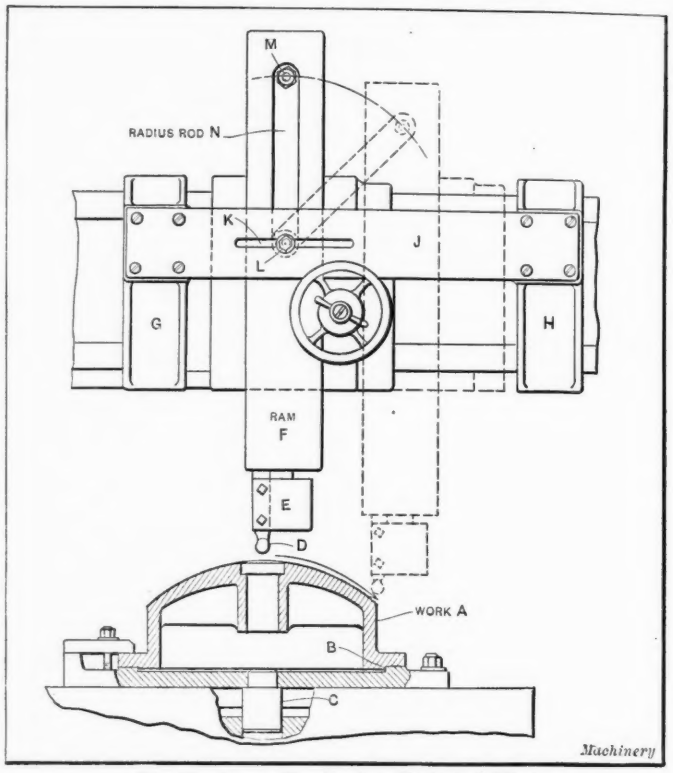

Fig. 17. Convex Turning in a Horizontal Plane

Convex Forming Attachment for the Vertical Turret Lathe

A simple arrangement for the vertical turret lathe which permits the simultaneous use of both the main head and side heads, is shown in Fig. 13. The work *A* is a tractor pulley of large size. This is held by the inside, in the jaws *C* which are mounted on the raising blocks *D*. The boring-bar shown may be used if desired, while the radius turning is taking place, as the radius attachment does not interfere in any way with the movements of the main head. The construction of this device is extremely simple and the results obtained by its use are very satisfactory. The upper and lower brackets

B and *N* are attached to the bed of the machine and carry the rods *K* and *M*, which support the forming plate *F*. This plate is cut at *G* to the desired radius, and the tool-steel roller *H* travels along the slot and forces the tool *E*, which is held in the side-head turret, to take a similar path, thereby producing the convex surface on the rim of the pulley. A tee-slot *J* is cut along the entire length of the side-head slide, and the roll *H* is fastened to a special bolt which can be adjusted to any position in the slot. The forming plate is also adjustable vertically, by sliding the rods up or down in the brackets.

Side-head Attachment using a Radius-bar

Another method for crowning the outside of a tractor pulley is shown in Fig. 14, a radius-bar being used in this case to

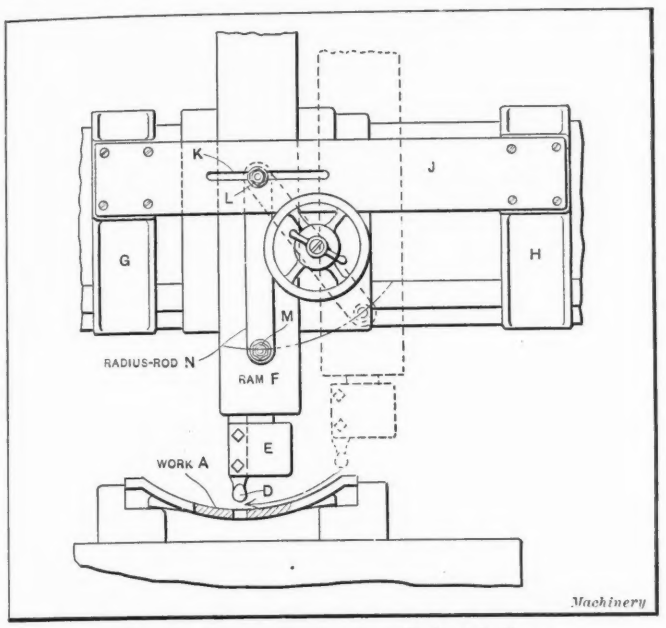

Fig. 18. Concave Turning in a Horizontal Plane

generate the desired curve. The work *A* is held, as in the previous instance, by the jaws *C* on the raising blocks *D*. The same brackets are also employed, but the plate *F* is not used for forming. It is slotted at *G* for adjustment only and a special screw or stud *H* is used in the slot as a pivot for the radius-bar *Q*. A tee-slot *J* is cut along the entire length of the side-head slide and receives a special stud *P*, to which the other end of the radius-bar is fastened. The down feed of the side-head is thrown into engagement when operating the device, and the tool *E* naturally follows the radial path controlled by the length of the radius-bar. This device is simple and good and only requires extra radius-bars in order to handle a great variety of work.

Vertical Boring Mill Attachment for Spherical Turning

The male member of a very large ball-and-socket pipe joint is shown at *A* in Fig. 15. The spherical portion, which is to be machined, has an outside diameter of forty-nine inches. This member fits the female portion shown in Fig. 16, and the attachments used for boring and turning are the same, although the locations and the tools are different. A special bracket *G* is mounted on the rail and is gibbed at the rear so that it can be adjusted easily. It is well gibbed at *H* to insure rigidity. The special ram *C* was made in the form shown, its lower end acting as a tool-holder for the tools *B* and *J;* the former is used for the outside turning and the latter for the inside boring. The ram itself is a steel casting of extra-heavy section on account of the excessive overhang required. The radius-rod *D* was fastened at the two ends by the screws *F* and *E*, and was made of the proper length to give the correct radius. A special arrangement, not shown in the illustration, permitted a side floating action to the saddle along the rail, when the down feed was engaged.

For handling the socket portion of the joint shown (Fig. 16), the entire mechanism was moved over on the rail far enough to bring the tools in the desired position for boring, the tool *J* being used for this purpose.

Attachment for Convex Turning in a Horizontal Plane

The work *A* shown in Fig. 17 is a steel casting which has been previously machined at *B*. It is held on a fixture (located centrally on the table by the plug *C*) and clamped down by the three clamps around the flange. Two brackets *G* and *H* are mounted on the rail and serve to carry the supporting plate *J*. As these brackets necessarily extend some distance in front of the rail they are strongly ribbed, as shown in the illustration. The supporting plate *J* has a slot cut in it at *K* for adjusting the pivot stud *L* in a longitudinal direction. This stud supports one end of the radius-rod *N*, and the other end is attached to the upper portion of the ram *F* by pivot stud *M*. A regular tool-holder at the lower end of the ram holds the tool *D*. No special arrangement is necessary to allow the saddle to "float" in a transverse direction, as the horizontal feed-screw is used in this case, the vertical feed being simply thrown out of mesh. This permits the ram to float vertically, as controlled by the radius-rod *N*.

Attachment for Concave Turning in a Horizontal Plane

The steel casting shown at *A* in Fig. 18 is turned concave by the same device as that illustrated in Fig. 17, the only difference being that the radius-rod *N* is pivoted to the ram below the supporting plate instead of above. The operation of the mechanism is exactly the same as that for the convex surface.

Many variations of the devices described in this article have been used for generating radial surfaces, but enough have been described to enable the reader to select a method most suited to the particular problem that may require a solution. Adaptations may be readily made to fit almost any condition likely to be encountered in general manufacturing.

* * *

A LIGHTNING CALCULATION

BY UNCLE JOSH

Considerable amusement may be derived by this mysterious trick of "lightning calculators." The "professor" announces that five numbers will be written, three by the audience, and two by himself, and that after the audience selects the first number, he will immediately give the sum of the five *before the rest have been selected.*

Thereupon, one of the audience writes, for the first number, for instance, 4,962,783 and the professor immediately announces that the sum will be, 24,962,781. To illustrate:

The audience selects for the first figure	4,962,783
The audience selects for the second figure	8,652,794
The professor writes for the third figure	1,347,205
The audience selects for the fourth figure	2,339,964
The professor writes the fifth number	7,660,035
The sum is found to be, as announced	24,962,781

This seems very mysterious, but is easily accomplished, as follows: For the sum, subtract 2 from the first number selected, and place the figure 2 to the left of it. Thus, subtracting 2 from 4,962,783=4,962,781, and placing a figure 2 before it makes it read 24,962,781.

The professor selects the third figure, by selecting such numbers that the figure in each column, added to the figure above it, will make nine.

Thus, the second figure being	8,652,794
He will write the third figure	1,347,205
The sum of each column=9	9,999,999
The audience then writes the fourth figure	2,339,964
The professor proceeds as before, writing	7,660,035
The sum in each column being 9	9,999,999

[If the number of horizontal rows of figures is increased from five to seven, the sum can be obtained by subtracting 3 from the first number and placing the figure 3 to the left, whereas for nine horizontal rows, subtract 4 from the first number and place 4 to the left, etc.—EDITOR]

* * *

The life of shop brooms can be greatly lengthened by dipping the brush in hot water before using. The glue water is made by using one teaspoonful of good liquid fish glue for each quart of hot water.

ONE-PIECE ARMATURE DISK TOOLS*

UNUSUAL TOOLMAKING METHODS EMPLOYED BY THE ROBBINS & MYERS CO.

BY DOUGLAS T. HAMILTON†

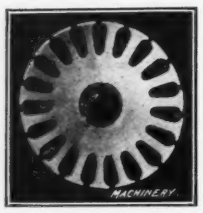

Fig. 1. Armature Disk

Armature disks are made from a grade of sheet iron 0.025 inch thick called "electric" iron. This material is used because of its permeability—low resistance to an electric current—and though very soft, it is difficult to cut out, the wear on the dies being enormous. The shape of these armature disks, as Fig. 1 shows, is such that it has been considered inadvisable by many manufacturers, to make the dies or punches solid because the thin strips of metal remaining are likely to warp in hardening and break, and if made solid, the repairing of them would be difficult if not impossible. The Robbins & Myers Co., Springfield, Ohio, well-known manufacturers of the "Standard" line of fans, motor and generators, make all types of armature and field punches and dies up to 10 inches in diameter from one solid piece of steel, and machine them to the shape required. This not only calls for good tool work, but it also demands particular care in hardening and subsequent operations.

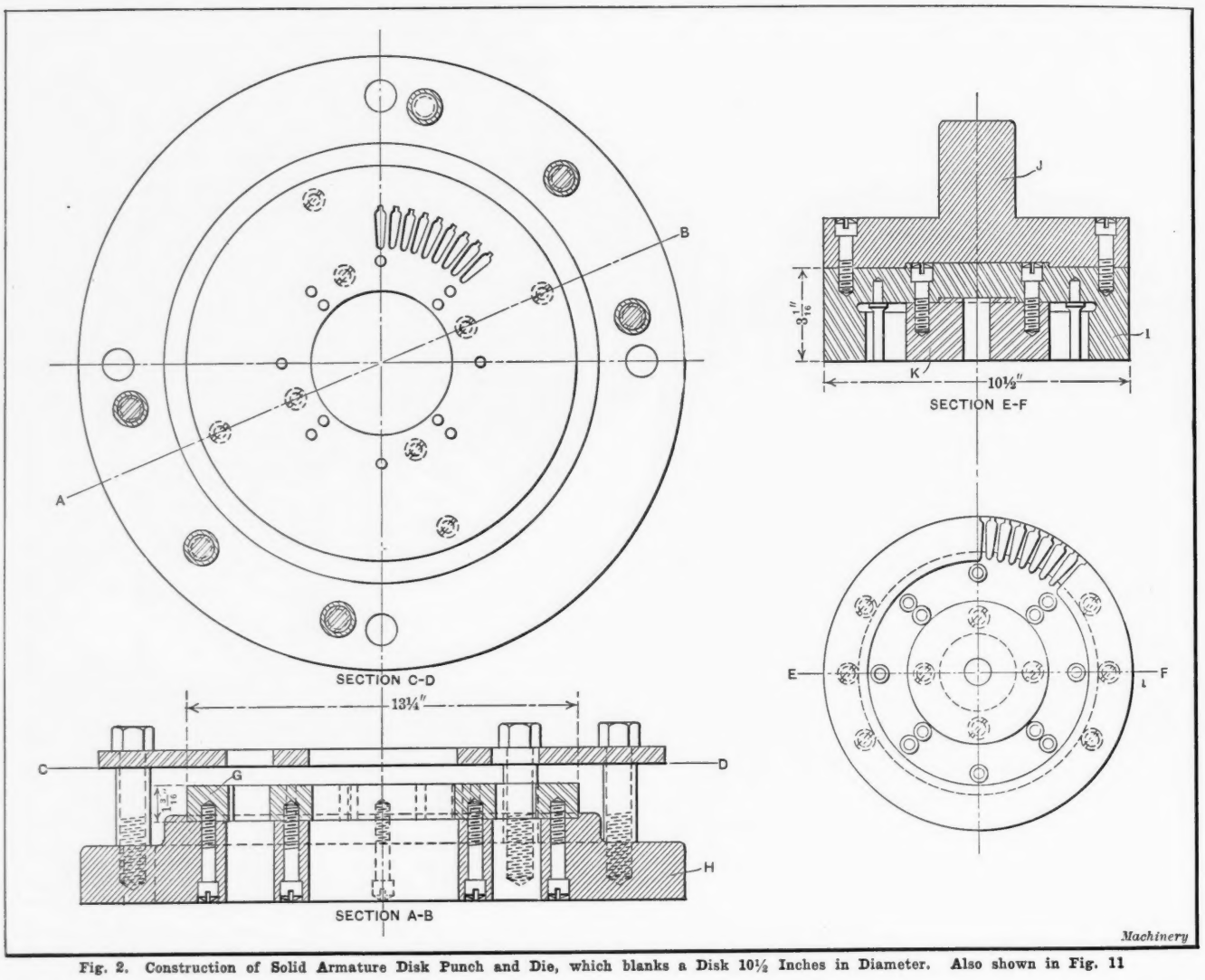

Fig. 2. Construction of Solid Armature Disk Punch and Die, which blanks a Disk 10½ Inches in Diameter. Also shown in Fig. 11

Construction of Solid Armature Disk Tools

The punch and die shown in Fig. 2 is not of the sub-press pattern, as is the usual practice followed in making sectional armature disk dies, but is of the plain blanking type of construction. The blanking die *G* is made from one solid piece of steel in which the required number of elongated slots are machined, as will be described later. The die fits in a counterbored seat in the die shoe *H* and is held in place by screws as shown.

The slitting punch *I* is made from a solid block of steel, which in this case is provided with a projection fitting in a recessed seat in the punch-holder *J*, to which it is held by screws. The punch *I* is also recessed to fit an additional plain blanking punch *K*, the latter cutting out a blank which is subsequently slit and made into a smaller sized armature disk *A*, Fig. 11. This method is used to economize in stock, and cut the scrap down to a minimum. The individual piercing punches *L* for the large armature disk *B*, Fig. 11, are driven into the punch-holder *J*, as illustrated. The prongs of the slitting punch *I* are formed by cutting a series of slots around the periphery of the blank and then shaping the individual prongs to the desired shape, as will be described later. The punch and die illustrated in Fig. 2 is the largest solid armature disk tool ever produced by the Robbins & Myers Co., and both the die and punch are made from solid pieces of "Ketos" non-shrinkable oil hardening steel.

Making Solid Armature Disk Dies

Armature disk dies, as previously mentioned, are made solid up to 10 inches in diameter, and are cut from round bars of special non-shrinkable oil hardening steel. The blank, after the center hole has been drilled, is placed on an arbor and turned on the external diameter in the lathe; it is then ready for working out the elongated slots which form the projections on the armature disks. The first step in this operation is to drill a series of equidistantly spaced holes entirely through the blank as illustrated in Fig. 3. The die block *A* in this case is driven onto a taper arbor which is held in the dividing

* For information on punch and die work previously published in MACHINERY, see "Drawing and Forming an Automobile Clutch Cone" in the November, 1913, number, and articles there referred to.

†Associate Editor of MACHINERY.

head on the milling machine. A bushing type of drill chuck is then inserted in the spindle of the milling machine, carrying a drill of the required diameter. The internal ring of holes is usually drilled first, then the size of the drill is changed and an exterior ring of holes is drilled, these two rows of holes forming the approximate length of the slots. Following this, a series of holes is drilled so that they just break into each other, and thus remove the intervening webs.

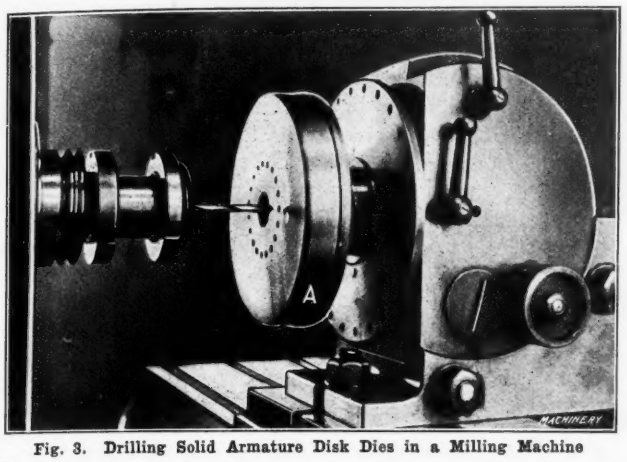

Fig. 3. Drilling Solid Armature Disk Dies in a Milling Machine

The next step is to finish-form the elongated slots, this operation being accomplished in the manner shown in Fig. 4. The die *A*, as before, is mounted on a tapered arbor, which is held in the dividing head on the milling machine, while slotting tools of the proper shape are held in the slotting attachment. The dividing head is held perpendicular and the slotting attachment is also set square, so as to produce a straight hole. The clearance angle is produced in a filing

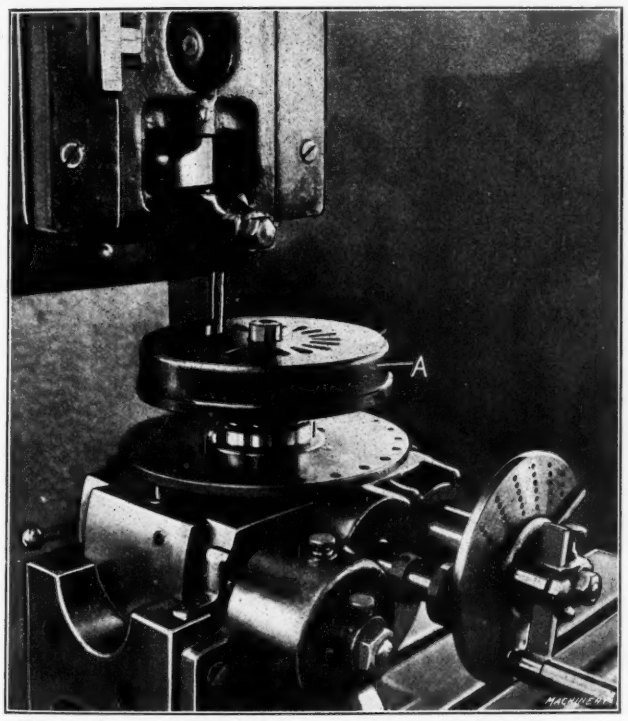

Fig. 4. Shaping Elongated Slots in a Solid Armature Disk Die, using a Slotting Attachment and Indexing and Dividing Head on a Milling Machine

machine as will be described later. The sides of the slots are machined first, after which the two arcs at each end of the oblong slots are machined. The outer arc has a slot cut in it. A tool of suitable shape is used to produce this slot after the arc has been finished and the slot cut to the desired length. The indexing attachment of the dividing head, of course, is used for spacing the holes correctly.

Finishing Operations on the Die Blank

After the elongated slots in the die have been machined to their approximate size, the final operation consists in filing them to the exact size. This is accomplished in the small bench filing machine as illustrated in Fig. 5. It consists of a table that can be set to the desired angle, which carries a file of such shape as to conform with the slots in the die. This machine is driven by an individual motor as illustrated, and in addition to bringing the slots to the proper shape it also produces the correct clearance angle. The clearance angle on armature disk dies is 0.003 inch on a side, the die blank being 1⅛ inch thick. It is necessary, therefore, to tilt the table over from the vertical line to an angle of about 7½ minutes.

The die blank is hardened and drawn before the punch is made and fitted to it. For hardening, a regular gas burning muffle furnace is used. The blank is placed in this furnace and brought to a temperature varying from 1375 to 1400 degrees F. The heating is done gradually and uniformly until the tools show a dark red throughout, indicating a temperature of about 1100 degrees F., before the heat is raised to the hardening point—1375 to 1400 degrees F. The tools are then dipped into linseed oil and left to cool, after which the temper is drawn very slowly to 250 degrees F. to relieve the strain. The hardening of solid armature dies calls for considerable ingenuity on the part of the toolmaker, as the least amount of shrinkage or warpage in the die would unfit it for use, and as it is of the solid type it would be practically impossible to do anything with it if distorted in hardening. It is therefore evident that not only must a good brand of steel be used,

Fig. 5. The Final Machining Operations on a Solid Die—filing the Elongated Slots to the Proper Size and Shape

but considerable care has to be exercised in order to obtain satisfactory results. However, it may be stated that the Robbins & Myers Co. have been using this type of die for a considerable period, and they have not lost one tool during the past two years in the hardening operation.

Slotting Armature Disk Punches

The punch is made in a similar manner to the die in that it is cut off from a round bar of stock, drilled, turned and recessed in the lathe and is then slotted as illustrated in Fig. 6. The punch *A* in this case is driven onto a tapered arbor which

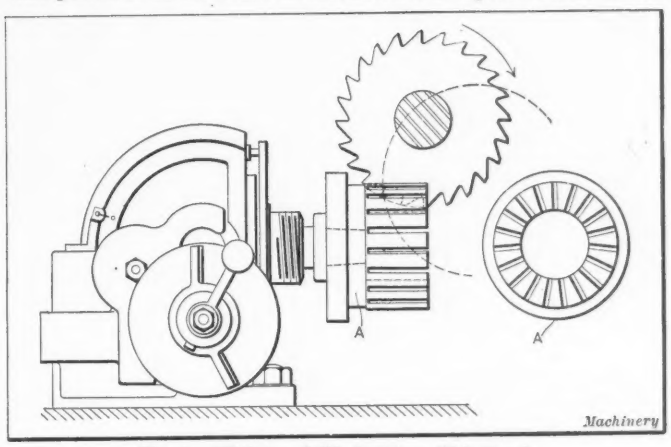

Fig. 6. Slitting a Solid Armature Disk Punch

is held in the dividing head of the milling machine and a slotting saw of the required thickness is used to form the individual members of the punch. Two cuts are taken; one cut is taken as indicated by the full lines in the illustration, after which the position of the cutter is changed and a second cut is taken. On some types of armature punches where the

slot between the individual members of the punch or prong varies in width at the inner and outer extremities, slotting saws of different thicknesses are used in order to reduce the amount of machining on the sides of the members. When this is necessary, the saw is not inserted as illustrated in Fig. 6, but is raised slightly, and the second saw also raised, the remaining web being machined out with a slotting attachment in the milling machine.

Finish-forming the Individual Members or Prongs

After the individual prongs of the armature punch have been formed by slotting, the next step is to form the inner and outer arcs. This is accomplished as illustrated in Figs. 7 and 8. In Fig. 7 the punch *A* is set up in a vertical position, for machining the inner arc of the prongs. Here it can be seen

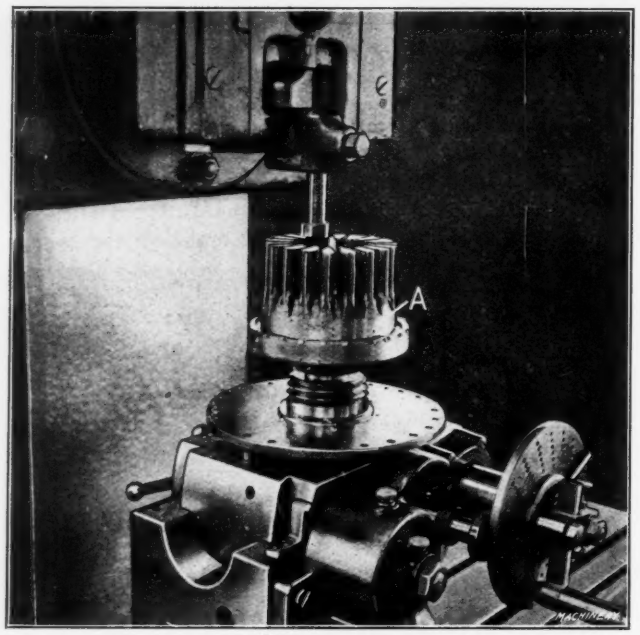

Fig. 7. Final Shaping Operation on the Inner Ends of the Punch Prongs, using a Slotting Attachment and a Dividing Head on the Milling Machine

that the dividing head is used for holding the punch, and the shaping tool is held in the slotting attachment of the milling machine. The shaping tool is so formed that it completes the arc on the inner edge of the prongs in one setting. The outer arc on the prongs is formed with the special milling cutter *B*, as indicated in Fig. 8, with the punch *A* held in a horizontal instead of a vertical plane. The milling cutter, in addition

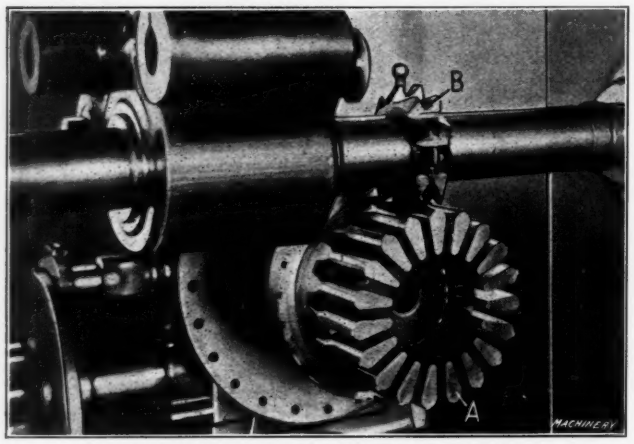

Fig. 8. Finishing the Outer Diameter of the Punch Prongs, using a Formed Milling Cutter

to forming the arc, also produces the slight projections on the punch that cut out the ring that will be left in the armature disk, or in other words, continues the oblong slot to the circumference. The milling cutter as illustrated completes this form of punch in one operation, and at the conclusion, with the exception of a slight touching up with the file, the punch is ready to be sheared into the die to obtain the final shape. The excess stock is filed away, and the punch sheared in several times until the shape has been produced for about ¼ inch. After this the punch is taken back to the milling machine and the excess amount of stock removed as indicated in Figs. 7 and 8.

Different Types of Armature Disk Tools

Armature and field disks are made of several different shapes to conform with the motor or generator in which they are used. Fig. 9 shows a follow type of armature disk punch and die for producing the disk *A*. The sheet is first perforated

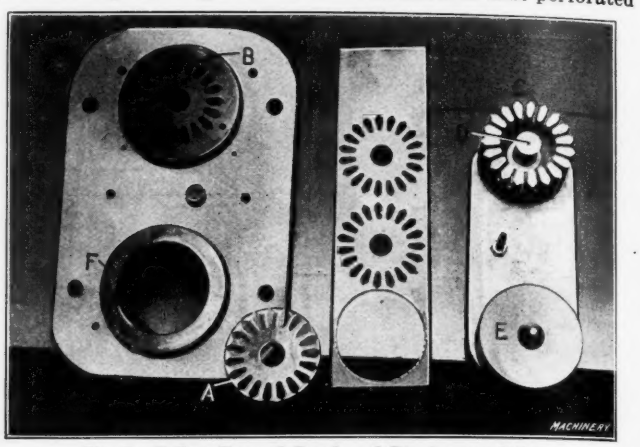

Fig. 9. Follow Type of Punch and Die for completing an Armature Disk in One Operation

by the solid die and punch *B* and *C*, respectively, and at the same time the hole is produced by the inserted punch *D*.

Owing to the relation of the blanking punch and die *E* and *F* to the perforating punch and die *C* and *B*, the punch press makes two strokes before a blank is cut out, when starting a new sheet. The chief reason for laying out the perforating

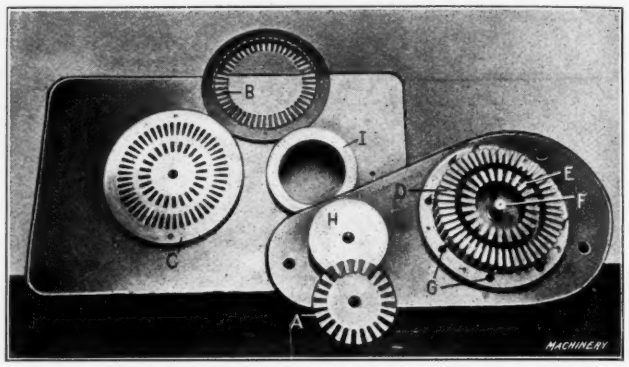

Fig. 10. Combination Follow Type of Punch and Die for completing an Armature Disk and slotting and piercing a Field Disk in One Operation

and blanking dies in this way is that it would be impossible to get them close enough unless made from the same piece of steel. Fig. 10 shows a follow type of die similar to Fig. 9, but of more interesting construction. These tools complete the armature disk *A* and slit and pierce the field disk *B* at each

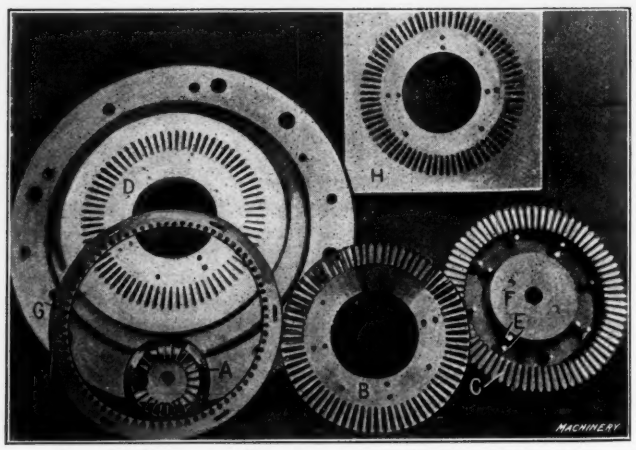

Fig. 11. Punch and Die for a Fan and Starter Field Disk and Other Pieces made from Same Sheet

stroke of the press. The field disk *B* is blanked out in a separate operation. The perforating die *C* is made from one solid piece of steel, while the punches *D* and *E* are made from two solid rings of steel fastened by screws to the punch-holder. The punch *F* which pierces the center hole in the armature

disk *A* is also an individual member. The piercing punches *G* for the field disk *B* are inserted around the outer periphery of the punch-holder as shown. Punch *H* and die *I* blank out the armature disk *A*.

Another interesting example of solid punch and die work is shown in Fig. 11. This illustration shows the punch and die presented in detail in Fig. 2, and also gives some idea of the number of blanks and the character of operations performed by it. The small field disk *A* is only blanked out by these tools and is pierced and slit in a separate operation. The large armature disk *B* is slit by the solid punch *C* and die *D* and is pierced by the inserted punches *E*, the center hole being produced by the separate punch *F*. It is blanked out from the sheet in a separate operation. The field disk *G* is another piece which is produced from the same sheet as the other parts shown in this illustration, but it is completed in a separate operation. The portion of the sheet *H* shows where the disk *G* is obtained.

An armature disk set of tools differing slightly from those previously shown is illustrated in Fig. 12. These tools are used to produce the armature disk *A* which is used in a 5 H. P. motor. The die *B* is one solid piece of steel machined out to the shape shown, while the punch is partly of segment

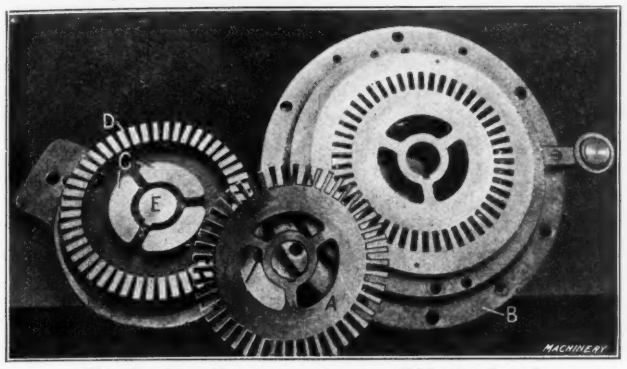

Fig. 12. Five Horsepower Armature Disk Punch and Die of a Semi-solid Construction

construction. Punches *C* for producing the arms are made from three separate pieces of steel let into the main slitting punch *D*, which is made from one solid piece of steel. Punch *E* is also an individual member. This armature disk is blanked out in a separate operation.

Fig. 13 shows an armature disk set of tools set up and in operation in a Toledo punch press. These tools are similar

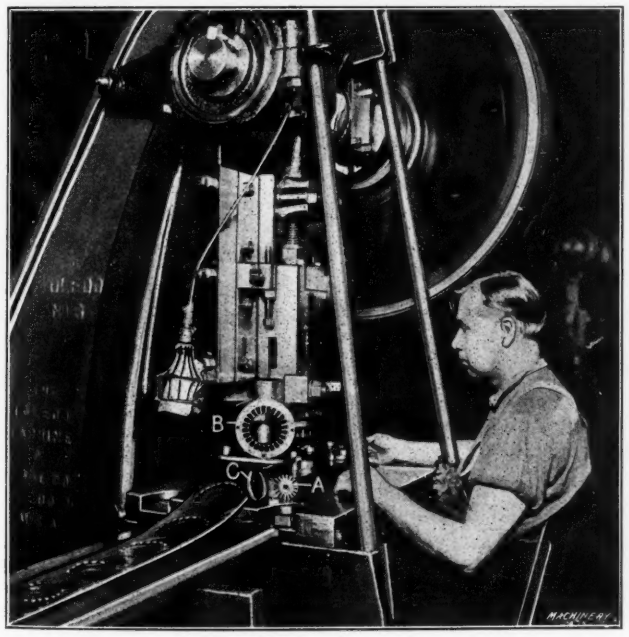

Fig. 13. Solid Armature Disk Punches and Dies in Operation—Note Method of saving Stock

in construction to those shown in Fig. 10. They produce the armature disk *A*, and pierce and slit the field disk *B*, the scrap being a ring *C*. The field disk *B* is cut out from the sheet in a separate operation. The sheet of stock has been pulled out from beneath the punches to show the operations more clearly. This illustration shows the method used to reduce the scrap to a minimum.

Life of Solid Armature Disk Tools

One remarkable feature that is particularly noteworthy about these solid armature disk tools, and the steel used in making them, is their long life and the large number of blanks which can be produced between grinds. Fig. 14 shows two die blanks; the one to the right has never been used and

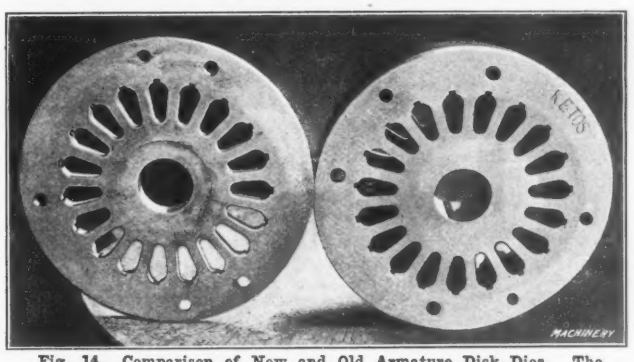

Fig. 14. Comparison of New and Old Armature Disk Dies. The Old Die has blanked 1,344,000 Armature Disks and has been ground down from 1⅛ to 3/16 inch in Thickness

is 1⅛ inch thick, whereas the one to the left has produced 1,344,000 blanks—16,480 blanks between grinds—has been ground eighty times, and reduced from 1⅛ to 3/16 inch in thickness. The solid punch also stands up satisfactorily and is ground an equal number of times. This is a rather unusual performance and is greatly in excess of what would be expected of the solid type of punches and dies as generally made. The clearance, as before mentioned, is only 0.003 inch on a side or 0.006 inch on the diameter of the elongated holes in the die. As the blank always retains the size of the punch —the scrap being the size of the die—the die can be worn down without affecting the character of the work produced by it.

* * *

SPEEDS FOR TURNING UNUSUAL MATERIALS

The *Practical Engineer* gives the following information on turning unusual materials: Slate, on account of its peculiarly stratified formation, is rather difficult to turn, but if handled carefully, can be machined in an ordinary lathe. The cutting speed should be about the same as for cast iron. A sheet of fiber or pressed paper should be interposed between the chuck or steadyrest jaws and the slate, to protect the latter. Slate rolls must not be centered and run on the tailstock. A satisfactory method of supporting a slate roll having journals at the ends is to bore a piece of lignum vitae to receive the turned end of the roll, and center it for the tailstock spindle. Rubber can be turned at a peripheral speed of 200 feet per minute, although it is much easier to grind it with an abrasive wheel that is porous and soft. For cutting a rubber roll in two, the ordinary parting tool should not be used, but a tool shaped like a knife; such a tool severs the rubber without removing any material. Gutta percha can be turned as easily as wood, but the tools must be sharp and a good soap-and-water lubricant used. Copper can be turned easily at 200 feet per minute. When machining commutators that is the speed commonly used. Light cuts are taken with a pointed tool and the surface is finished with a wooden buff lined with glass paper. This buff is in the form of a 90-degree segment and is approximately 1¾ inch thick. It is held against the commutator with the point of an ordinary tool and is fed back and forth across the surface. In this way the segments are gradually ground down until there is not the slightest gap or break between the copper segments and the mica insulation. Bath stone such as is used in the construction of pillars for balconies, etc., can be turned at 150 feet per minute, and the formation of ornamental contours is quite easy. Marble is a treacherous material to turn. It should be cut with a tool such as would be used for brass, but at a speed suitable for cast iron. It must be handled very carefully to prevent flaws in the surface.

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AUTOMATIC MACHINERY FOR DANGEROUS WORK

Machinery is designed to function automatically in order to insure uniformity of product and to reduce the cost of attendance. Another reason for designing automatic machines is to save life and limbs. The growing recognition of the fact—chiefly due to liability acts—that employers must bear the responsibility for accidents makes imperative the elimination of dangerous apparatus wherever possible. Some trades are inherently dangerous, and in these, simple automatic machines for performing the operations entailing risk to workmen should effect a considerable reduction of yearly casualties.

There are operations in the manufacture of ammunition which expose the workmen to danger of injury by explosion. They might cost no less if done on automatic machines, because the upkeep of the machines might wipe out the saving of attendance, but the greater safety of operation doubtless would make the change profitable both from a humanitarian and a monetary point of view.

Take, for example, the loading of the cases for a certain powerful explosive shell with cordite. Holes in the sides of the case must be provided, but on account of the difficulty of loading the cordite in cases having holes it seems necessary to load first and drill the holes afterward. Obviously, this is a very dangerous operation. A spark struck by the drill when passing through the wall into the chamber is sure to cause an explosion and probably the death or serious injury of the workman. Granted that the procedure must be as outlined, it seems little less than criminal not to provide automatic drilling machines in bomb-proof inclosures for drilling the holes. Such machines can be readily provided which would work rapidly and as efficiently as hand machines. One life saved by providing automatic drilling machines would be worth all the cost of the equipment.

* * *

BROACHING ROUND HOLES

Broaching keyways and holes of other shapes than round has been practiced many years, but not until the last decade in which automobile manufacturing has developed so greatly did broaching become a commercial practice of widely recognized importance. One of the unexpected applications of the broaching machine is for finishing round holes. The finishing of round holes by broaching instead of by reaming, may seem strange to those unfamiliar with the conditions met with in alloy steel gears, but some alloy steels are extremely difficult to finish satisfactorily by reaming. The steel is tough and the chips have a tendency to catch on the reamer blades and score circumferential grooves in the hole. The cost of reamer upkeep when working on alloy steels is heavy as compared with that for carbon steel.

The broaching process applied to finishing round holes in alloy steel parts is rapid and satisfactory. Not only is the tool upkeep cost lower than with reaming but the finish is superior to that obtained by reaming unless extraordinary care is taken. An advantage of minor importance is that the tool markings appear longitudinal instead of circumferential. This favors proper distribution of the lubricant and insures smooth and long wear of running parts.

* * *

STUDS VS. CAP-SCREWS

An important detail of steam and gas engines, air compressors, hydraulic machinery and other fluid-actuated mechanisms is the means employed for holding cylinder heads and valve covers in place. The choice of the designer lies between studs with nuts and cap-screws. What are the advantages and disadvantages of studs and cap-screws?

Studs are preferred to cap-screws, especially on heavy machinery for the following reasons: 1. A stud and nut can generally be screwed tighter than a cap-screw because of better alignment, smoother threads and reduced effect of torsional elasticity. 2. A stud and nut is less likely to break than a cap-screw when making repairs. In case a nut is rusted fast on a stud it can be split with a cold chisel, but a cap-screw "seized" in the casting is twisted off. This means that the broken part must be drilled out and a new cap-screw provided to take its place. The loss of time and extra labor incident to breakages of cap-screws are important disadvantages when making repairs. 3. Covers secured with nuts and studs can be loosened and tightened without serious deterioration of the fastening means. The nuts on studs can be loosened many times without appreciable wear of the threads, but not so with cap-screws. They soon wear the cast-iron threads and become loose and are likely to strip after being used a few times. 4. Studs have the advantage of holding gaskets in place while a cover is being applied. This is an important advantage in erecting when the parts are heavy and applied with difficulty. 5. A stud made from a round bar is stronger than a cap-screw turned down from a hexagon bar. The latter uses the weakest part of the metal at and near the center for the body.

The Ohio State University department of mechanical engineering will make a series of tests of studs and cap-screws with the view of determining all the advantages of each. Prof. William T. Magruder, head of the mechanical engineering department, will be glad to receive suggestions for the tests and arguments for and against the two types of fastenings.

* * *

ANTIQUATED TOOL-ROOM EQUIPMENT

We are sometimes surprised to find machine shops equipped with first-class tools in every department but the tool-room. In this important department are old lathes and other machines in good condition, but of old design. They did good work, but are too weak to take heavy cuts without excessive vibration and springing out of alignment. The management evidently believed that weak machines were good enough for toolmakers because they are seldom required to do heavy work. This is a mistaken notion. There is no reason why a tool-room lathe should take three or four cuts to reduce a piece when lathes in the main shop are doing the same work in two cuts.

The tool-room should be equipped with strong, heavy machines, for two very good reasons. First, in order to prepare the work quickly for the finishing operation, and second to take heavy reduction cuts when required with a minimum of chatter and spring. Toolmaking is, in the main, nothing more nor less than regular machinists' work with a touch of refinement in the finishing processes. Smoother finish and closer limits are the rule, and they are most efficiently obtained on machines that are sturdy as well as accurate.

STABILITY OF THE MACHINE TOOL BUSINESS

The growth of the machine tool business in the last twenty years has been unprecedented. In 1893 there were comparatively few American builders of lathes, planers, milling machines, boring mills, automatic screw machines, drilling machines, shapers, slotters and other machines for metal working, commonly known as machine tools and their accessories. The number has increased to about two hundred and the capital invested has increased in still greater ratio. At the beginning and during this twenty-year period there have been three distinct dull times, 1893, 1903 and 1907, but within the period the number of failures of machine tool builders was astonishingly small. Probably no other industry consisting of so many actively competing concerns building a long-lived product can show such a record. The record still holds. During the present year, which toward the close undeniably has been a dull time in the machine tool trade, there has not been so far one serious failure. This fact speaks volumes for the stability of the business and the conservatism with which it is conducted.

The last ten years have been marked by the development of a new vehicle—the automobile—and the past six or seven years by the building of enormous plants for its manufacture. The equipping of these plants with standard and special machine tools has created a great market that to a certain degree was unhealthy. It could not last indefinitely. With the slacking of demand for the higher-priced motor cars there have come several failures and discontinuances of automobile concerns which has resulted in throwing a considerable number of second-hand machine tools on the market. These tools have affected the market for new machinery detrimentally, of course. Thus, in the automobile business, the machine tool builders have had an enormous market to supply, for which a number of concerns have perhaps unwisely expanded. Now that the market is restricted and a few of the former buyers are now in a sense competitors, some hardship is inevitable.

The changes in the tariff naturally have caused a tightening of purse strings until such time as the ultimate effect can be seen. German machine tool competition may affect certain lines injuriously for a time, but years will be required for the German manufacturers to obtain a firm foot-hold in this country. During that time our manufacturers will be improving their methods and product so as to keep ahead of foreign countries. The future is full of promise with little to discourage the American machine tool builder. The development of American mechanical appliances for all sorts of purposes must go on, and that progress means unlimited demand for the basic means of production, that is for lathes, planers, drilling machines, milling machines, grinding machines, automatic screw machines, shapers, boring mills, boring machines, slotters and the special machine tools characteristic of modern machine shop equipment.

* * *

SPEEDS AND FEEDS FOR COLD SAWING METALS

The selection of speeds and feeds for cold sawing is one of the many phases of machine shop practice which cannot be regulated by fixed rules. The design and construction of the machine and saw, as well as the grade of material to be cut, cause wide variations in both speed and feed. The average output or number of pieces cut for each grinding of the saw is another factor to be considered. One prominent manufacturer of cold saw cutting-off machines states that for sawing 0.30 carbon, open-hearth machine steel bars 5 inches diameter, a feed of 1 inch per minute and a peripheral speed for the saw of approximately 45 feet per minute would be used. This speed and feed is regarded as economical when using the vanadium steel high-carbon blades. As an example of this rate of cutting, 1600 pieces were sawed off in one machine with an average output of 145 pieces for one grinding of the saw. For some classes of work a feed of 2 inches per minute and a speed of about 45 feet is employed, but under average shop conditions a feed of ¾ inch per minute is considered conservative when cutting 0.30 open-hearth steel with a saw that is in good condition.

When selecting speeds and feeds, it is important to consider the output for one sharpening of the saw. In one shop 200 pieces of special analysis steel and 800 pieces of open-hearth steel (varying from 3¾ to 4¼ inches diameter) were cut at one grinding of the saw. While it may be feasible to cut various grades of steel at the rate of 1000 pieces with one grinding of a high-speed steel saw, the experience of the company referred to is that on high-carbon tool steel and special alloy steel, such as chrome-nickel, etc., the best economy in grinding the saw will be obtained by using a feed of about ½ inch per minute with a surface speed for the saw of approximately 30 feet per minute. When using the speed and feed mentioned, if the saw averages 100 pieces per grinding the output is considered satisfactory. It has been found that some of the special analysis steels cut quite freely as, for example, 3½ per cent nickel steel which is sawed as easily as open-hearth 0.30 per cent carbon steel. On the other hand, some of the softer grades of stock, such as open-hearth machine steel having about 0.15 per cent carbon, do not cut as freely as stock with a higher percentage of carbon. This is because the softer steel is inclined to roll up into the throats of the saw teeth and, if too much heat is generated in the cutting the chips will fuse more or less to the teeth. A good deal of this soft stock, in bars 8 inches diameter, has been cut with a saw speed of 45 feet per minute and a feed of about ⅝ inch per minute. This rate of cutting is considered the most economical for the saw when using vanadium high-carbon blades. Some grades of chrome-nickel stock seem to cut quite freely, whereas steel of another make is cut with difficulty and, in some instances, the use of a high-speed steel saw is necessary. Moreover, steel of one make may cut quite differently from that of another make, although the analysis in both cases may be the same; consequently, the speed and feed that will prove most economical must finally be determined by actual tests. Of course it will be understood that the size and power of the machine must also be considered. As to phosphor-bronze, some grades can be cut very easily whereas some of the bronzes used for gears, etc., are very hard to cut and the edge of the saw is inclined to glaze over; hence it is difficult to give even a general idea of the speeds and feeds.

Another well-known manufacturer of cutting-off machines gives the following data on the time for cutting various sizes of steel stock: Eighty-one pieces 3⅜ inches diameter, 2 hours 27 minutes; 210 pieces, 4 inches diameter, 7 hours 27 minutes; 54 pieces, 5 inches diameter, 2 hours 22 minutes; 57 pieces, 6 inches diameter, 2 hours 58 minutes; 684 pieces, varying from 3⅜ to 6 inches in diameter, 26½ hours. In the last example, the smallest number of pieces of the same size was 2 and the largest 210. The feed was 2 inches per minute and cutting speed 48 feet. The time for cutting 46 pieces of axle steel 7¼ inches in diameter was 3¼ hours, the feed being 1¾ inch per minute. When cutting flat stock 1⅛ by 9⅛ inches, several bars were stacked and cut simultaneously, a total of 246 pieces being cut off in 1 hour 37 minutes. The material was low-carbon steel, the feed 3⅞ inches per minute, and the cutting speed 85 feet per minute.

Still another concern gives time data for various grades of metal: Time for sawing steel forging, 6⅛ inches in diameter containing 0.74 carbon, 1.12 manganese, 0.30 nickel, 7½ minutes; tool steel bar 2½ inches diameter, 4 minutes; tool steel bar 0.50 per cent carbon, 3½ inches diameter, 3½ minutes; Krupp chrome-nickel steel bar 4½ inches diameter, 5 minutes; Krupp chrome-nickel steel bar 6 inches diameter, 8 to 10 minutes; 6½-inch bar, 0.20 per cent carbon, 5 minutes; 6-inch bar, 0.30 per cent carbon, 4½ to 6 minutes; 8-inch bar of high-carbon steel, 13 minutes; 8-inch diameter hard bronze ingot, 6 minutes.

All these data represent actual practice and are given as a general guide, although it is necessary, of course, to make considerable allowance for the design of the saw as well as the size and power of the machine.

A STUDY OF THE STUB TOOTH SYSTEM OF GEARING*

DETERMINATION OF THE LEWIS FORMULA FACTOR y FOR STUB TOOTH GEARS

BY LLOYD G. SMITH†

Owing to the demand for stronger and smoother running gears in machines where the power transmitted is high and the space limited, there is now coming into common use the stub-tooth system of gearing in which the angle of obliquity is increased to twenty degrees and the length of the teeth decreased to about eight-tenths that of the standard 14½ degree involute tooth. Accurate information regarding the strength of these teeth is lacking and it was the purpose of this investigation to determine correct values of the factor y in the Lewis formula for the strength of gear teeth as applied to this system of gearing. The two forms of stub teeth used in this country—that recommended by the Fellows Gear Shaper Co., 25 Pearl St., Springfield, Vt., and that recommended by the R. D. Nuttall Co., Pittsburg, Pa.—are the ones with which this investigation is concerned.

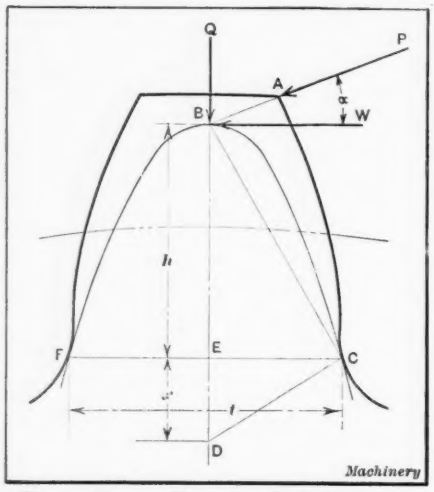

Fig. 1. Diagram illustrating Derivation of the Lewis Formula

The Strength of Gearing—Lewis Assumptions

In 1893, Mr. Wilfred Lewis, after making a considerable study of the subject of the strength of gear teeth, derived a formula for the safe load that could be transmitted by a gear. He was the first investigator to take into consideration the form of the tooth profile and the fact that the line of action of the pressure is always perpendicular to the surface. When gears are cut accurately, his formula gives very satisfactory results and with a few corrections for the number of teeth in contact, etc., it is almost universally used in gear design.

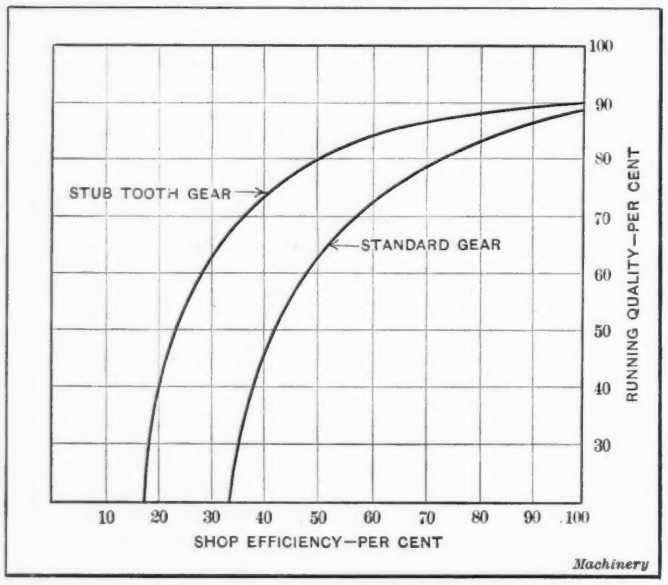

Fig. 2. Diagram from Transactions of A. S. M. E. for 1908 showing Relative Efficiency of Stub Tooth and Standard Gears

Mr. Lewis assumed that all of the load on the gear was concentrated at the end of one tooth, its line of action being perpendicular to the surface AC as shown in Fig. 1. The actual force P was resolved into a tangential force W and a radial force Q. The tangential force produces a bending stress in the tooth, while the radial force produces a uniformly distributed compressive stress. When the material of which the gears are made is stronger in compression than in tension, this radial component is a source of strength, but when the material is of about the same strength in tension and compression it is a source of weakness. For small angles of obliquity α this compression does not amount to more than 10 per cent of the total stress and on this account was neglected by Mr. Lewis. The tangential force W he assumed to be equal to the force transmitted at the pitch circle. This last assumption, although perhaps as much as 10 per cent in error for small pinions, gives values of the stress on the safe side and so may be considered accurate enough for practical purposes.

TABLE I. PROPORTIONS OF FELLOWS STUB TOOTH GEARS

Pitch	Thickness of Tooth, Inches	Addendum, Inches	Clearance, Inches	Whole Depth, Inches
4	0.3927	0.2000	0.0500	0.4500
5	0.3142	0.1429	0.0357	0.3214
6	0.2618	0.1250	0.0312	0.2812
7	0.2244	0.1111	0.0278	0.2500
8	0.1963	0.1000	0.0250	0.2250
9	0.1745	0.0909	0.0227	0.2045
10	0.1571	0.0833	0.0208	0.1875
11	0.1309	0.0714	0.0179	0.1607

Machinery

Force Analysis

To obtain the weakest section of the tooth, Mr. Lewis constructed a parabola CBF (Fig. 1) passing through B, the application point of the tangential force W, and tangent to the tooth profile at C and F. This parabola encloses a cantilever beam of uniform strength and it can be readily seen that the weakest section of the tooth lies along CF. The resisting moment of this section is:

$$\frac{SI}{C} = \frac{Sft^2}{6} \qquad (1)$$

where S = allowable fiber stress;
f = face width of the gear.

The bending moment is Wh, hence:

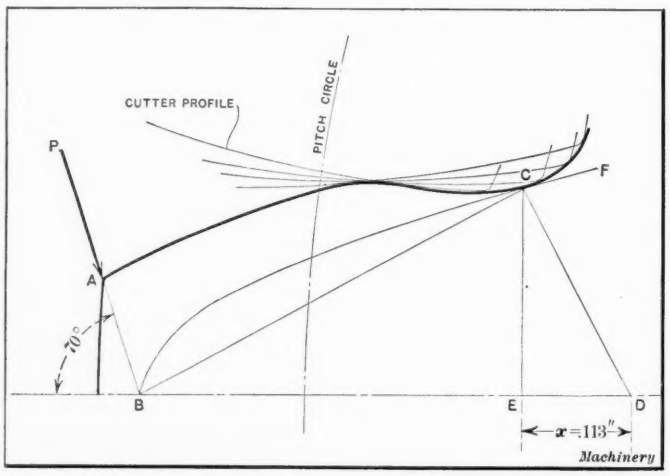

Fig. 3. Method of laying out Gear Teeth to determine Values of x and y

$$Wh = \frac{Sft^2}{6} \qquad (2)$$

From the geometry of the figure:

$$h = \frac{t^2}{4x} \qquad (3)$$

* For further information on the subject of stub tooth gearing see "The Stub Gear-Tooth," published in MACHINERY October, 1911; "Design of Automobile Transmission Gears," October, 1910; "The Stub Tooth Gear," April, 1908; and "Calculations for Short Tooth Gears," July, 1907.

† Address: 5474 Greenwood Ave., Chicago, Ill.

Then $$W = \frac{2Sfx}{3} = Sfp' \times \frac{2x}{3p'}$$

where p' = the circular pitch.

Representing the ratio $\frac{2x}{3p'}$ by the symbol y, we have:

$$W = Sp'fy \qquad (4)$$

The value y is thus seen to be dependent upon the tooth profile and the pitch of the gear. By drawing the tooth profiles for gears with various numbers of teeth, Mr. Lewis was able to calculate the value of y for the standard involute system, and he found that the following equation very closely fitted the values he obtained.

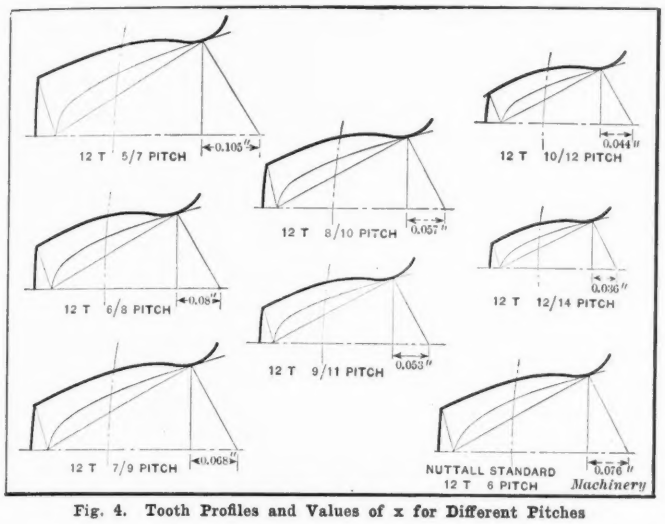

Fig. 4. Tooth Profiles and Values of x for Different Pitches

$$y = y_r - \frac{a}{n} \qquad (5)$$

in which y_r = the value of y for rack teeth;

a = constant depending upon angle of obliquity;

n = number of teeth in gear.

A mathematical analysis of a rack tooth outline shows that the value of y_r is given by the following equation:

$$y_r = 0.1278\,p\left(\frac{t}{0.728} - z\right) \qquad (6)$$

in which t = thickness of tooth at pitch line;

z = addendum;

p = diametral pitch.

Stub Tooth Systems

To meet the demand for gear teeth that are stronger than the standard 14½ degree involute, various methods of increasing their strength may be resorted to. Two of these methods are as follows: (1) shortening the addendum and keeping the standard angle of obliquity; and (2) increasing the angle of obliquity and preserving the standard height of the tooth. The stub tooth system is a combination of these two methods, in which the height of the tooth is decreased to about 0.8 the standard height and the angle of obliquity increased to 20 degrees.

The chief advantage of this system is that the teeth will transmit greater loads, and this fact is taken advantage of in the construction of machine tools, hoisting machinery and automobiles, because with the same quality and amount of material, greater strength can be obtained. The stub tooth gears run smoother than gears with the standard 14½ degree involute teeth, due to the decreased impact, because for a given strength and length of face, the pitch is smaller and consequently the number of teeth in mesh is greater. Stub tooth gears are almost universally used by automobile manufacturers, and they report that the action is smoother and the wear less than with standard gears. Mr. Norman Litchfield in the Transactions of the American Society of Mechanical Engineers for 1908 reports that they have given excellent service on the New York subway trains. Mr. E. R. Fellows in the same volume of the Transactions presents the chart shown in Fig. 2, which is based on actual experience. The curves apply to stub tooth and standard gears with "shop efficiency" plotted against "running quality." By shop efficiency he means the relative conditions under which the gears operate and that 100 per cent would only be attained under laboratory conditions, 90 per cent representing first-class commercial conditions and 70 per cent the common conditions in an average shop. By running quality is meant the relative noiselessness of the gears, 100 per cent signifying absolutely noiseless operation and 90 per cent the best condition actually obtainable. The curves show that under the very best conditions the two gears operate about equally well, but under average commercial conditions, the stub tooth gear is decidedly superior.

Forms of the Stub Tooth System

In this country, there are two forms of the stub tooth system in common use, both using an angle of obliquity of 20 degrees, but differing in the length of the addendum. The older of these is that recommended by the Fellows Gear Shaper Co. in which the pitch is designated by two numbers written as a fraction, the numerator of which represents the diametral pitch and the denominator the diametral pitch of a standard gear having the same addendum. Thus in the 4/5 pitch, the gear would have a diametral pitch of four and an addendum the same as on a standard gear of five pitch, *i. e.*, 1/5 of an inch. Table I gives the proportions of the Fel-

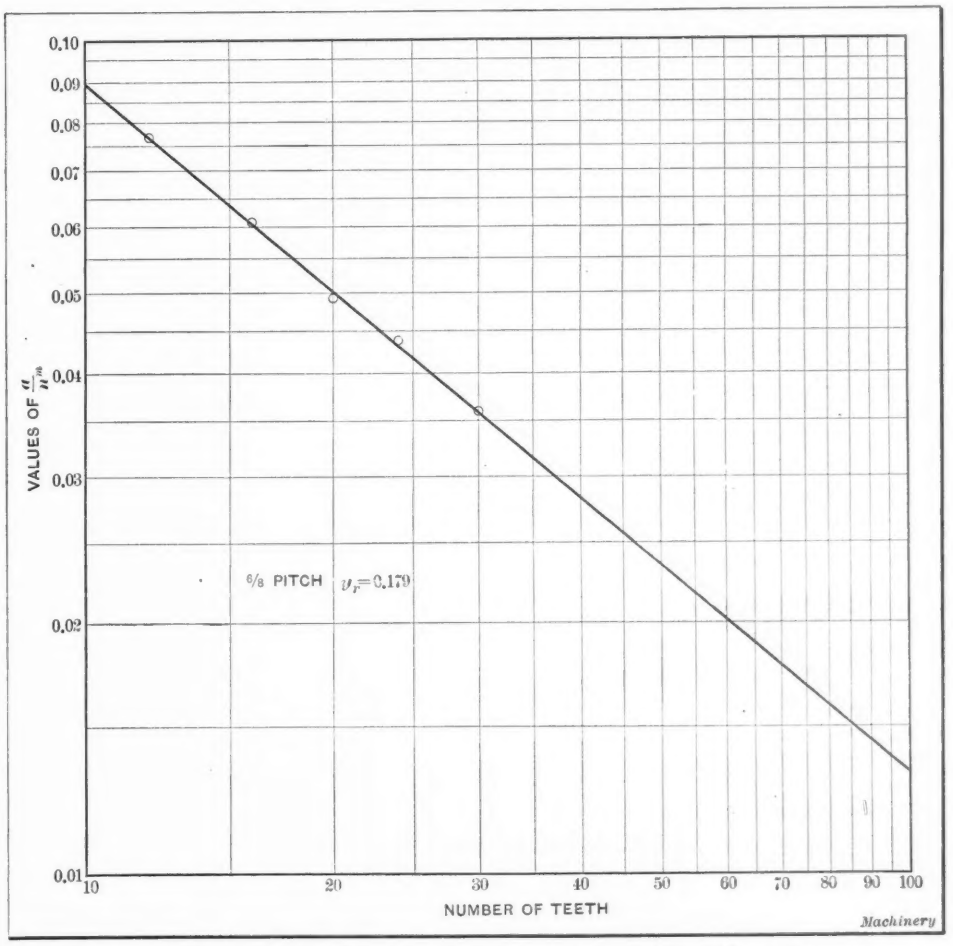

Fig. 5. Diagram showing Values of a ÷ n raised to mth power from which Values of n raised to mth power and Factor y are derived for the 6/8 Pitch Gear

lows stub tooth gears. The other system was originated by Mr. C. H. Logue of the R. D. Nuttall Co., and he uses an addendum equal to 0.25 of the circular pitch and a dedendum of 0.30 of the circular pitch. In the Fellows system the ratio of the addendum to the circular pitch varies from 0.228 to 0.272, and in order to make his system uniform, Mr. Logue took a mean value of 0.25.

Determination of the Strength Factor and Method of Drawing Profiles

In order to determine the value of y for a certain gear of a given pitch, it is necessary to lay out a tooth to some magnified scale in the same manner that Mr. Lewis did (illustrated by Fig. 1) measure the distance x and compute y. In this investigation, this has been done for a great many pitches, using a scale of 10 to 1, except for the large pitches where the drawings would become too large. For pitches 5/7 and 6/8 a scale of 8 to 1 was used and for 4/5 pitch a scale of 6 to 1. Fig. 3 illustrates the method of laying out the teeth. Before laying out the teeth the profile of the cutter tooth was drawn on tracing paper with the addendum equal to the dedendum of the stub tooth gear, and the diameter equal to that of a 24-tooth gear. The gear cutter was taken this size on the recommendation of the Fellows Gear Shaper Co. The tooth profiles of gears with various numbers of teeth were then drawn accurately on tracing paper, with the face from the base circle out a true involute and the flank and fillet generated by the point of the cutter tooth, as the pitch circles of the gear and cutter were rolled together.

TABLE II. VALUES OF a AND m

Pitch	4/5	5/6	6/8	7/9	8/10	9/11	10/12	12/14	Nuttall System	Standard 20-degree Involute
a	0.505	0.535	0.605	0.760	0.690	0.490	0.540	0.440	0.592	0.540
m	0.760	0.800	0.830	0.930	0.890	0.780	0.800	0.720	0.820	0.790

Machinery

Having thus obtained the profile, the action line AB (Fig. 3) of the force at the end of the tooth was drawn normal to the involute, *i. e.*, at 20 degrees to the vertical. In order to get the parabola BCF passing through B and tangent to the profile, a considerable number of parabolas, differing but slightly from each other, were drawn on cards, so that they could be slipped in under the tracing paper and adjusted to enable the point of tangency C to be determined. The line BC was then drawn and CD and CE drawn perpendicular to BC and BD, respectively. The length x was measured as accurately as possible with a Starrett steel scale and the value of y computed. Two or more profiles of the same tooth were sometimes drawn and it was found that the values of x usually checked within 1 or 2 per cent. Fig. 4 shows the tooth profiles and values of x for various pitches.

Method of Plotting

We have already determined an exact method of computing y_r in Equation (5):

$$y = y_r - \frac{a}{n}$$

If any method could be found for obtaining the value of $\frac{a}{n}$, the problem of determining the value of y would be very simple. The use of logarithmic cross-section paper makes the plotting of all such functions as $y = bx^a$ very simple, because the curve becomes a straight line with a slope a. In Equation (5) $\frac{a}{n}$ is a function of the same character, and when so plotted for different values of n, it should give a straight line with a slope of -1. Advantage was taken of this peculiar property of logarithmic paper by first carefully computing y and y_r for five different gears for each pitch, and then plotting the corresponding values of $\frac{a}{n}$. Due to unavoidable errors in calculating y, the points did not all lie exactly in a straight line, but somewhat as shown in Fig. 5, which gives values of $\frac{a}{n^m}$ for the 6/8 pitch teeth, and so it was considered best to use five points and draw an average line through them instead of drawing a line through just two determined points.

It was found that instead of the function being $\frac{a}{n}$ it was $\frac{a}{n^m}$ for stub tooth gears with the slope of the line, *i. e.*, the value of m, lying between 0.72 and 0.93. Values of a and m are given in Table II.

The values of y in Table III were then obtained by simply subtracting the value of $\frac{a}{n^m}$ obtained by means of the proper chart from y_r. If this method of plotting had not been used, it would have been necessary to lay out gears with from 12 to 200 teeth and measure x on each drawing, a task which would have taken five or six times as long to do.

Conclusions

One of the interesting facts that came out in this investigation was that the function $\frac{a}{n}$ as given by Lewis does not apply to stub tooth gears, and that a function of this nature to be correct should have an exponent other than unity in the denominator. In view of this discovery, it was thought strange that for standard teeth this exponent should be exactly unity and the function be $\frac{a}{n}$, or as Lewis gives it for 20 degree involute teeth $\frac{0.912}{n}$. Consequently Lewis' values of $\frac{a}{n}$, derived from his values of y, were plotted and it was found that the function really is $\frac{0.54}{n^{0.79}}$; but as the function $\frac{0.912}{n}$ is so much simpler to calculate, and is correct within 5 per cent, one might be justified in using it.

Owing to the varying ratio of the addendum to the circular pitch in the Fellows system, the values of y are different for

TABLE III. VALUES OF y IN LEWIS FORMULA FOR STUB TOOTH GEARS

No. of Teeth	Fellow's System								Nuttall System
	4/5	5/7	6/8	7/9	8/10	9/11	10/12	12/14	
12	0.096	0.111	0.102	0.100	0.096	0.100	0.093	0.092	0.099
13	0.101	0.115	0.107	0.106	0.101	0.104	0.098	0.096	0.103
14	0.105	0.119	0.112	0.111	0.106	0.108	0.102	0.100	0 108
15	0.108	0.123	0.115	0.115	0.110	0.111	0.105	0.103	0.111
16	0.111	0.126	0.119	0.118	0.113	0.114	0.109	0.106	0.115
17	0.114	0.129	0.122	0.121	0.116	0.116	0.111	0.109	0.117
18	0.117	0.131	0.124	0.124	0.119	0.119	0.114	0.111	0.120
19	0.119	0.133	0.127	0.127	0.122	0.121	0.116	0.113	0.123
20	0.121	0.135	0.129	0.129	0.124	0.123	0.118	0.115	0.125
21	0.123	0.137	0.131	0.131	0.126	0.125	0.120	0.117	0.127
22	0.125	0.139	0.133	0.133	0.128	0.126	0.122	0.118	0.128
23	0.126	0.141	0.134	0.135	0.129	0.128	0.123	0.120	0.130
24	0.128	0.142	0.136	0.136	0.131	0.129	0.125	0.121	0.131
25	0.129	0.143	0.137	0.138	0.133	0.130	0.126	0.123	0 133
26	0.130	0.145	0.139	0.139	0.134	0.132	0.128	0.124	0.134
27	0.132	0.146	0.140	0.140	0.135	0.133	0.129	0.125	0.136
28	0.133	0.147	0.141	0.141	0.136	0.134	0.130	0.126	0.137
29	0.134	0.148	0.142	0.143	0.137	0.135	0.131	0.127	0.138
30	0.135	0.149	0.143	0.144	0.138	0.136	0.132	0.128	0 139
32	0.137	0.150	0.145	0.146	0.140	0.137	0.134	0.130	0.141
35	0.139	0.153	0.147	0.148	0.143	0.139	0.136	0.132	0.143
37	0.140	0.154	0.149	0.149	0.144	0.141	0.138	0.133	0.145
40	0.142	0.156	0.151	0.151	0.146	0.142	0.140	0.135	0.146
45	0.145	0.159	0.154	0.154	0.149	0.145	0.142	0.138	0.149
50	0.147	0.161	0.156	0.156	0.151	0.147	0.144	0.140	0.151
55	0.149	0.162	0.157	0.158	0.152	0.149	0.146	0.141	0.153
60	0.150	0.164	0.159	0.159	0.154	0.150	0.148	0.143	0.154
70	0.153	0.166	0.161	0.161	0.156	0.152	0.150	0.145	0.157
80	0.155	0.168	0.163	0.163	0.158	0.154	0.152	0.147	0.159
100	0.158	0.171	0.166	0.166	0.160	0.156	0.154	0.150	0.161
150	0.162	0.174	0.170	0.169	0.164	0.160	0.158	0.154	0.165
200	0.164	0.176	0.172	0.171	0.166	0.162	0.160	0.156	0.167
Rack	0.173	0.184	0.179	0.176	0.172	0.170	0.168	0.166	0.175

Machinery

each pitch, but in the Nuttall system this ratio is constant, y being the same for all pitches. The values of y in Table III indicate that stub tooth pinions with less than 25 teeth are about 25 per cent stronger than the standard 20 degree involute and 40 per cent stronger than the standard 14½ degree involute. For larger gears the difference is in favor of the stub tooth but is not quite so marked.

A table of the values of y for the Fellows stub tooth gears appeared in MACHINERY for October, 1910, computed by Mr. M. Terry. They were derived from Lewis' values for the 20 degree involute tooth by multiplying them by the ratio of the addendum of the standard gear to that of the stub tooth gear. His assumptions, which at first glance seem to be fairly reasonable, are altogether unwarranted when the original method of finding the weakest section of the tooth and computing y is considered. Mr. Terry's values are entirely too high for every gear except the 12-tooth pinions, the values for the larger gears being as much as 10 per cent to 15 per cent too large. The chance for error in determining the distance x would seem to be considerable, since the fillet must be generated by rolling the pitch circles of two gears together, and the point of tangency of the parabola determined by a somewhat approximate method; but as a matter of fact, when two or more lay-outs were made of the some tooth, the values checked very closely.

* * *

DIAMETER INDICATOR STOP FOR TURRET LATHES

The usual practice followed in producing duplicate formed work in a turret lathe is to control the movement of the cross-slide by a stop and thus hold the work to the required diameter. An experienced operator with an ordinary cross-slide stop can hold the work to within 0.0005 inch plus or minus limits on the diameter, but when an inexperienced operator is

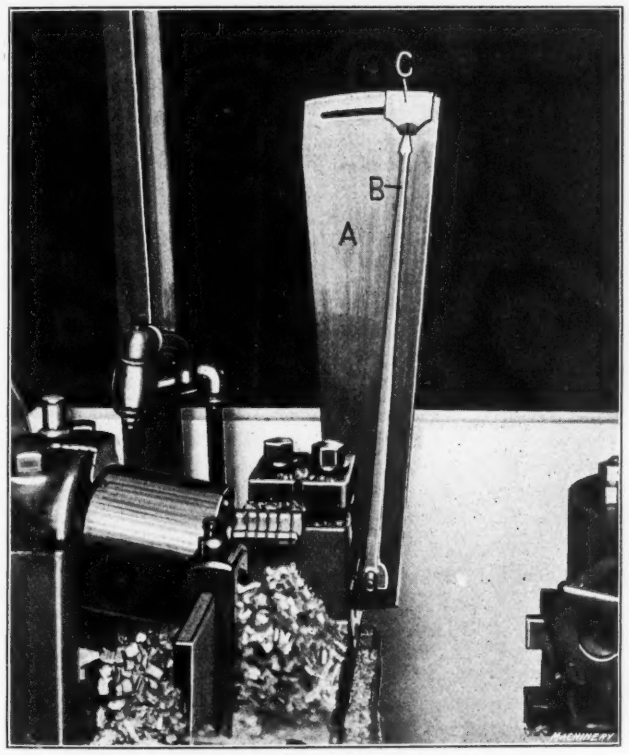

Fig. 1. Diameter Indicator Stop for Turret Lathes

put to work on a turret lathe, these limits are rather close. It takes some time for the inexperienced operator to get just the right feel on the screw of the slide.

In order to eliminate defective work, the Mail-om-eter Co., Detroit, Mich., has worked out an ingenious device which has been applied to all its turret lathes. The device shown in Figs. 1 and 2 comprises a steel plate A which is fastened by cap-screws to the cross-slide and consequently moves with it. This plate carries an indicator needle B and an adjustable datum plate C, the latter being held in place by a thumb-screw shown in Fig. 2. The lower end of the indicator needle B, which is bent at right angles, passes through the plate A and is beveled to an angle of about forty-five degrees in a vertical plane. Working against this vertical beveled face of the indicator needle is a fulcrumed lever D mounted on a bracket fastened to the plate. The lever is kept in contact with the tapered end of the indicator needle by a coil spring E and is operated by an adjustable stop F, which is held in a bracket fastened to the face of the cross-slide carriage.

When in operation the forming tool is advanced toward the work and fed in to the correct depth, the lever D is brought

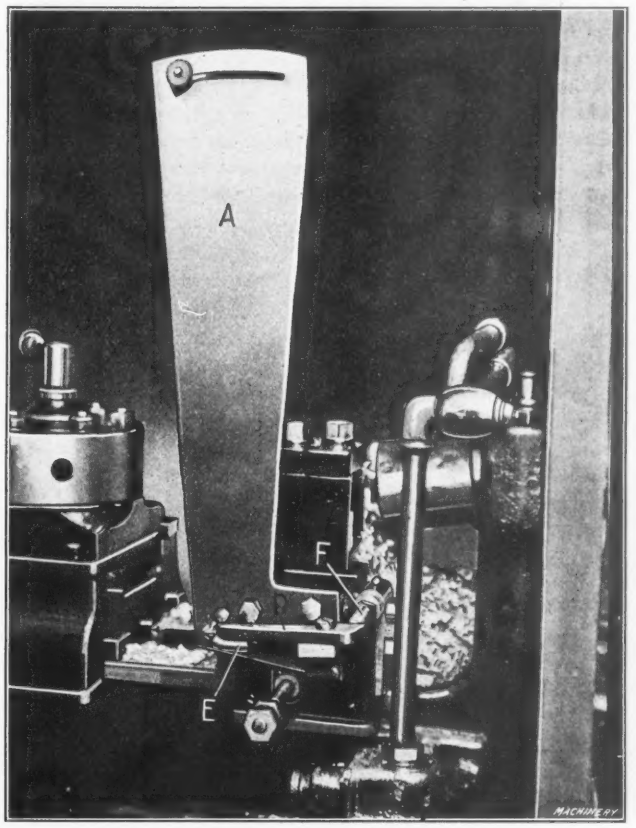

Fig. 2. Rear View of Diameter Indicator Stop showing how it is operated

in contact with the stop F, transmitting a movement to the needle B which moves across the face of the plate indicating when the correct diameter is reached. The movement of the indicator is worked out on a ratio of about 10 to 1, and as a rule where extremely accurate work is required (no limit of variation being allowed) only one line is provided on the adjustable datum plate.

The machine is set up for any particular job by the foreman of the department and then all the operator has to do is to bring the cross-slide forward until the indicator points to the mark indicating the correct diameter. With this arrangement it is easily possible for an inexperienced operator to hold the work within limits of 0.0005 inch, plus or minus, and without any difficulty at all, keep within a variation of 0.001 inch. As soon as the tool becomes dull, which would mean that the work would be made larger in diameter, this condition is easily noted by the finish left on the work. The tool is then taken out, sharpened and the indicator reset. While it would appear that the machine could not be operated as quickly with the indicator needle as with the ordinary cross-slide stop, this is not the fact in actual practice, especially where accurate work is demanded. When nearing the correct diameter, with the ordinary cross-slide stop the operator has to cut slowly so as not to put any unnecessary strain on the slide; while with the indicator stop the slide can be brought forward at an even rate until the needle points to the predetermined point. It is therefore evident that as far as rapidity of operation is concerned, this device does not retard production.

D. T. H.

* * *

As a general rule, it seems that there is too much architecture and too little utility about many of our public buildings, and too much utility and too little architecture about most of our factories.

ETHICS OF CONTRIBUTING TO THE TECHNICAL PRESS

SOME OPINIONS OF READERS ON THE RELATIONS OF EMPLOYERS AND EMPLOYES REGARDING PUBLICITY

The article in the November number on "Ethics of Contributing to the Technical Press" brought out several interesting contributions. The opinions of the different writers may be summarized as follows

An employe is not justified in publishing patentable ideas, but it is not wrong to describe general manufacturing methods —publicity would show progressiveness of firm. J. L.

Before making public manufacturing methods, an employe should have an agreement with his employer, provided the methods are special and only used in that particular plant. Workmen should not be barred from describing general methods. Other things being equal, the man who can express his ideas in writing is more valuable to his employer. W. R. H.

When an employe designs improved apparatus for an employer, or offers a valuable suggestion, he should ask permission to publish, even though no compensation has been received. If the suggestion or improvement is ignored by firm, employe has moral right to make public. W. C. B.

The right of an employe to describe manufacturing methods in the technical press depends largely upon the value of the methods. Nothing should be published that would be objectionable to employer. The employe should be competent to exercise his own judgment as to value of methods. N. G. N.

This is not so much a question of ethics as of the attitude of executives. If the article deals with developments of firm, the attitude of those in charge should be ascertained; if it does not, the employer has no moral right to interfere. The liberal-minded employer knows that the subordinate who writes articles is not only interested in his work, but is training himself to think clearly and express his ideas accurately. J. S. M.

The article by Mr. Brickner in the November number of MACHINERY is no doubt interesting to many who have contributed to the technical press. Of course, an employe who worked on certain machinery where patentable ideas were being developed, would not be justified in giving out any information. He would be expected, as a part of his work, to keep in confidence these improvements. As far as general work is concerned, it does not seem that an employe would be doing wrong to write articles describing methods of manufacture and improved tools used. The value to the employer of the methods, tools, etc., would not be impaired by publication, but publicity would rather reflect the efficiency and progressiveness of the firm. The employer may say that the articles would give his competitors an opportunity to apply the ideas developed with his money to their own work. This argument, however, would not hold good, because workmen going from shop to shop to work would prevent methods from being kept private. A certain class of work for which an employer may have spent considerable time and money in designing up-to-date tools, may be handled in another shop in different ways with just as efficient results as to accuracy and rapid production. The question of an employe withholding ideas from an employer would seem to depend upon the nature of the improvements. If they were of a different nature than his regular work, the ideas would, without doubt, be his own property. If his improvements applied directly to the machinery on which he worked, it would seem that his efforts were due largely to the experience and study of his special work. In this case, it would appear that the just thing to do would be to offer his ideas to his employer who should recognize his loyalty and ability in a substantial way. If an employer did not do this, his employes would have no incentive for developing anything of value.

Camden, N. J. JOHN LEAFSTROM

In his communication on the "Ethics of Contributing to the Technical Press," in the November number, Mr. A. J. Brickner is undoubtedly right in assuming that many writers are frequently in doubt as to just what they are privileged to write for publication.

The question, as Mr. Brickner says, is a moral rather than a legal one, but this fact in itself is of slight importance, for an employer has it in his power to make it exceedingly unpleasant, to say the least, for the employe who acts in opposition to his rules or wishes, without the assistance of the law.

It is safe to assume that no contributor cares to antagonize his employer in any way. This being the case, it would seem best in all instances for the employe, if he does not thoroughly understand his employer's views in the matter, to "sound" him and come to some mutually satisfactory agreement, before undertaking to make public methods or processes of manufacture peculiar to his employer's establishment. It makes no difference by whom the methods or processes were devised; if they are a part of the manufacturing system of this particular employer, they belong to him and he alone has the right to publish them or to permit them to be published.

If the employe designs a tool, a fixture, die, or a special machine to perform a certain operation on his employer's product, any new idea incorporated in the tool is universally considered the employer's. As a rule, a workman is asked to sign an agreement to that effect before he is employed, in many manufacturing establishments. This does not mean that an employe is not privileged to write for publication what he pleases when the subject has no exclusive relation to his employer's plant or product. He would be a narrow-minded manufacturer, indeed, who would, on general principles, deny an employe the right to contribute to the technical press. The workman who is not only inventive and original but who can express his ideas in writing, is a more valuable man, other things being equal, than the man who cannot, and writing for the technical press is of great value in helping a man to express his thoughts clearly.

If an employe has original ideas or knows of methods in use in more than one establishment which have not been described, he has as much right to make them public as he would have to publish his personal views in a local newspaper. In other words, if the idea is wholly his, or belongs to no one in particular, there can be no question at all in the matter, either legal or moral. If the employe, in the course of his work, applies some device or idea of his own to a machine or process of his employer's and if the same device or idea could be applied generally to similar machines or processes and does not have any particular relation to the employer's plant, then the employe might consider himself free to write on the subject. Still, as previously remarked, if there is the slightest doubt on the contributor's part as to his employer's attitude on the subject of contributing, the wise course naturally would be to settle the doubt before it is too late.

Rochester, N. Y. W. R. HUMELBAUGH

When an employe makes a suggestion, or designs an improved apparatus for a manufacturer, even though no material compensation has been received by the person making the suggestion or design, it is advisable to ask permission to submit it for publication. If no compensation has been given, permission to publish would probably be granted, but if a firm accepts a suggestion or design and pays something for it, then the one making the suggestion has no right to submit it for publication or even ask such a privilege, as it is then the firm's property. Again, suppose John Henry makes a suggestion and it is not accepted or is totally ignored (this has been done by the officials of some concerns), although John knows it to be a big improvement over the method in use; then he has a moral right to publish the information and Blank & Co. have no "kick."

The writer would like to narrate an incident which occurred in a place where he was once employed. John Henry was a young draftsman, who got the writing "bee in his bonnet" and started out to write up the whole equipment of the shop. Early in the game one of his articles came under the superintendent's notice, whereupon John received a summons to his sanctum, where he received a lecture and advice. On another occasion, John wrote an article by permission of the superintendent, which came under the president's notice. The article was of an unimportant nature and John told the head of the firm that he had permission to write it and wanted to know what harm had been done. The president remarked that he did not believe in the "education of the masses." This gives an idea of the sentiment of at least one firm in regard to writing for the technical press. As a rule, the officials of concerns do not like to have anything pertaining to the equipment published, even though it is generally known.

New Britain, Conn. W. C. BETZ

Concerning A. J. Brickner's queries in the November number, the writer has made it a point to contribute nothing that, in his opinion, an employer might find objectionable or harmful. Permission of my superiors to make "kinks" public is rarely requested, on the grounds that in my regular everyday work I am given credit for being able to exercise judgment in the company's interests and, therefore, am certainly competent to use that same judgment in matters that are less difficult to decide.

Much depends upon the value of the method to the employer. For example, my company makes use of a process of machining that no one else, to my knowledge, uses. The method is quicker, more economical, and more accurate than the usual methods, yet the company is not keeping it in strict secrecy. We are simply given to understand that the method is "new" and that it is one of the reasons why the company is able to maintain its present good scale of wages. Would I write a description of this process for the technical press? No, I did not have a hand in its development. We give our chief engineer credit for the method, and I feel that if anyone has a right to make it public he has. As the company is honest and square, the employes should be just as honest and square in return. The company and the chief engineer would have good grounds for objecting to the exploitation of this process, although, in my opinion, competitors would be rather slow to adopt it because of the expense that would necessarily be entailed in changing from old to new methods.

An associate once described a manufacturing method in detail, giving cost figures, test data, and every point of importance. He had first obtained his employer's permission. A competitor read the article, was naturally much interested, and managed to secure an interview with my friend. He seemed much surprised that his competitor would consent to the publication of matter of such seemingly vital importance. As it happened, however, the manufacturing costs of the two companies were about the same, so the only thing they had to fear was the small competitor who might be able to undersell the larger concerns by getting a line on costs through such publicity. The second large competitor sent a verbal message through my associate to the first competitor, to the effect that he "admired his nerve," but believed it better policy to keep certain things under cover, especially costs. Both of these companies are still the largest in their line of manufacture.

Another friend recently described an improved method for tabulating and plotting data, and in the article he gave credit to no one but himself, incidentally mentioning the fact that a large corporation was using the system with success. Because he did not ask permission and give his superiors due credit, he was rather severely censured, but it was admitted that the publication of the article would do the company no harm and perhaps would be beneficial to other companies that might be looking for more efficient tabulating and plotting methods. My friend still insists that he had a moral right to do as he did. As he expressed it, "——— is sore because I beat him to it. He would have written it up himself had he thought of it first." He assumed all credit because he believed the article would thus receive better editorial attention.

An employer certainly has a right to refuse publicity of his methods. The government recognizes the right of privacy in taking census data, in assessing, and in other ways, but if an employe chooses to make public what he knows about his employer's business there is usually nothing to stop him but his own conscience or his own judgment. So, according to my way of thinking, the whole matter hinges on personalities and conditions. No fixed rule can be made.

N. G. NEAR

The articles on "System Carried to Extremes" and "The Ethics of Contributing to the Technical Press" in MACHINERY for November, each seem to call for some comment. While these subjects appear to be widely separated they are often really correlative, because much which is wrong in the attitude of many concerns on both subjects is treaceable to the same causes, *viz.*, lack of cooperation, hence lack of understanding or *vice versa*, and incompetence. Lack of proper understanding of motives, aims and purposes is probably responsible for more that is deplorable than any other single cause.

It is the plain duty of any department head to cooperate with the other department heads and rectify anything wrong in mutual relations which may come to his notice. The chief engineer who permits a rule that there should be at least three views on all drawings, no matter how simple the part, is certainly not cooperating with the one who established the rule. If he was, there would be no such rule. The person who established the rule had a lack of understanding as to what constitutes a good and sufficient drawing. In this respect at least he appears to have been incompetent and to have failed to ask the advice of someone who was.

A man once dreamed that he was pursued by the "Evil One" and was making a hasty flight across fields. He impatiently kicked a jack-rabbit to one side saying, "Get out of my way and let someone run who can." Systematizers and others establishing rules often have such dreams in regard to their own ability, it would appear, and, being over self-confident, fail to cooperate.

The episode of the time cards also indicates a lack of understanding. Two of the main objects of such cards are to secure fairly accurate costs and to show up things which are abnormal and therefore require attention. In the case cited, a draftsman charged time spent in studying up improvements on a small detail to another larger job because he feared the time actually spent would be criticised. He thus defeated the purposes for which the cards were intended. Now if the results obtained were worth the time expended he should have charged all the time to the job. If the correct record on the cards was the means of starting an investigation he could have frankly stated his case, which, being creditable, should do him no harm.

The foregoing is based upon the idea that the right should prevail, as it does under fair-minded, honest and competent executives. Of course, we all know that there is the other variety and most of us have, at times, been hampered and annoyed by their short-sighted tactics, until it sometimes seems that too much honesty is not always the best policy, especially if it causes things to move with more friction.

It would seem from M. T.'s story that the troubles observed were mainly due to foolish rules, probably established by incompetents, or what amounts to about the same thing, good rules foolishly interpreted or too inflexibly applied. A little cooperation between fair-minded competent men should speedily adjust such matters. In the absence of such cooperation the best attitude toward such rules is often to believe in the old saw, "rules are made but to be broken," and when it seems justifiable consider yourself at liberty to break them with impunity. The establishing of rules is not the office or aim of system, and the establishing of a rule fixing a limit to salaries for any class of work (which is mentioned by M. T.) is not only in direct opposition to the ideas upon which most modern systems are based, but seems both foolish and uncalled for, because it serves no good purpose and does much

to discourage the employes. What is the use of establishing such a rule when it may be found both expedient and highly desirable to break it? To be consistent, if you limit the earning power of your employes you should also limit your own earning power and say: This concern will not earn over ten per cent of the capital invested per annum. Anything over this amount earned will be returned, pro rata, to the customers. If you consider an employe as a mere machine, do you imagine that the cost of developing this machine to its present state of perfection when taken as capital invested can be multiplied by a percentage of profit and by adding the proper cost of maintenance thus arrive at a just limit to salaries? If you do you have neglected to take into account that the probable duration of the mechanism has, in this case, a value to the machine itself. Even if you tried to be fair in this particular your ideas of proper maintenance and those of the machine are very likely to vary widely. Modern system may attempt to fix the rate for the performance of a certain amount of work but it should not attempt to limit the earning power of the individual if he gives value received in what he produces, whereas the fixing of a limit to salaries is an attempt in this direction.

Now regarding the ethics of contributing to the technical press, this is also a matter run largely by rules and in its practical workings is often not so much a real matter of ethics as of the attitude of the officers of the concern, their personality and the rules they may have established. The main difference between such rules and the variety mentioned in the foregoing, is that a rule regarding the publishing of matter is an arbitrary statement of the concern's policy in this respect and the breaking of such a rule would probably be classed as insubordination—an offense calling for reprimand or discharge. When no such rule exists the only logical thing to do is to ascertain the attitude of those in charge, if the proposed article deals with their work. If it does not, and is not prepared on the employer's time, the writer fails to see wherein the employer is concerned. There is, however, a class of executives who seem to think that if a man is on a salary basis instead of an hourly rating, his entire time belongs to the company. This class looks with a jealous eye upon any activities other than those from which they can see a direct benefit to the concern. The writer does not believe an employer has any moral right to assume this attitude unless he clearly states it before engaging the employe, and even then, unless the emoluments are so exceptional as to justify such an attitude, its ethical aspect is cloudy because it is an unnatural restriction upon the personal liberty of the employe.

The attitude of employers on the subject presents many inconsistencies, personality entering as a dominant factor in many cases. Some cases within the writer's experience are given in the following:

Mr. A is a public spirited citizen of the type who says he can get all the office boys he wants at three dollars a week but that he knows a boy cannot live on three per, so he pays him five. A's chief engineer, C, is the sort who raises a man's salary before asking for it. Says he does not believe it should be necessary for a man to use "a better position proffered" as a club to secure an advance.

Now C promised B a photo-print of a cut from A's catalogue, to illustrate an article B proposed publishing. A would not permit this, saying that it was the general policy of the company to have nothing published relative to their work excepting what was used in connection with their advertising literature. Whether A feared the use of the picture in question would rob his publicity experts of some of their fire, or whether he doubted the ability of B to write a creditable article is unknown, but some weeks later halftones of the device appeared in the dailies in connection with a discussion of labor troubles. B published his article minus the desired illustration, as he was bound to do under the circumstances, while the reporter for the daily, not being in A's employ, simply used his camera. Both A and C were liberal minded men, yet the ruling seemed narrow to B.

Another example: Concern D maintains an expensive bureau of safety, employs two physicians (one always on the job), equips wash rooms, furnishes storm coats for outside work, etc., "for the good of the service," but the concern is so secretive about its business that any information whatever about the equipment is absolutely refused. Even a twist drill salesman could not find out approximately how many drills they used a year as a basis upon which to quote prices. An employe publishing an article dealing with their work would undoubtedly be discharged. With this concern one need not be in doubt as to their attitude, but whether they gain or lose by it is problematical.

Another sidelight on the subject is illustrated by the following: Draftsman E had done considerable work on a special machine for chief engineer F. In the course of developing the designs, E learned a number of interesting things about the practical application of theory to design which would have made a good article. E proposed writing such an article but F said he, himself, wished to read a paper on the subject before a society of engineers, after which he had no objection to E's proposed handling of the subject. However, F never prepared the paper, E finally lost interest in the matter and the readers of MACHINERY lost a good article. Frequently the officers of a concern have no objection to the proper variety of articles, but the man who could and would prepare them is prevented by someone a little higher up, who thinks he himself should have the glory, but who actually does nothing; a sort of bow-wow-in-the-manger's attitude whether so intended or not.

Sometimes the official who passes upon the desirability of publishing articles mistrusts the ability of the one proposing to prepare it. Therefore, for an initial attempt it is probably best to prepare the article before asking permission, then submit it to your immediate superior with a request for his opinion. By this procedure you can demonstrate your ability and probably secure his cooperation. The liberal-minded man is glad to know that his subordinates are taking an intelligent interest in things, and he knows that the writing of articles is a mighty good training toward clear thinking and concise expression, as well as a means of developing correct ideas instead of erroneous ones; and, knowing that the old days of the trade secret bunco-game are gone forever, he generally lends a helping hand instead of placing obstacles in the way of the aspiring technical writer.

Some concerns are as hungry for free advertising as an opera star and, if permitted to do so, would monopolize much space in the technical journals by laudatory descriptions of their methods and product. Now properly managed periodicals do not cater to this spirit. They are looking for articles of merit only, which, in their judgment, will interest and benefit their readers. If an article incidentally reflects credit upon a concern or an individual, they are fair minded and desirous that all credit should be given where due, and occasionally make favorable editorial comment; but it is on a basis of what appeals to them as being meritorious. In view of this, it is desirous in the preparation of articles to eliminate as much as possible, mention of the men or concern where the work is done and stick closely to the development of the subject in an impersonal manner, which lessens the chance of giving offense to anyone's ideas on the ethics of the matter.

If an article is properly prepared, does not deal in personalities, violates no confidences, does not hand out "back door information," and presents matter worth while in a readable form, the author's own judgment as to the ethics involved in publishing it should be as good as anyones, but he should remember that the attitude of his superiors is very likely to be an arbitrarily assumed one instead of being based upon ethical considerations.

Philadelphia, Pa. JOHN S. MYERS

* * *

A furnace lining which will resist very high heat may be made from 40 parts, by weight, of fine asbestos, and 60 parts of water glass. The asbestos and water glass are mixed with enough water to make the whole pasty so that it can be worked. This mixture, says the *Brass World*, is useful for patching or plugging cracks, as it does not crumble as readily as other compositions made from fire-clay.

LUBRICATING SYSTEMS FOR CUTTING TOOLS—1

VARIOUS METHODS OF SUPPLYING AND DISTRIBUTING LUBRICANT TO CUTTING TOOLS

BY JOSEPH G. HORNER*

The lubrication of cutting tools, like many other details of machine tool practice, has made great advances during recent years. Systems and methods that were at one period considered special and adapted only to a certain class of machine, are now applied commonly to various other types. New developments have also had their effect in increasing the demand for better methods of lubrication. There is considerable variation in the methods of lubricating tools, not only on different classes of machines, but on machines of the same type, the reason being two-fold: Either the work does not require the application of a lubricant, or the amount and manner of supplying the lubricant varies, ranging from a slight drip to a profuse flooding under pressure; this depends upon the nature and extent of the cut. For example, a light milling operation with a single cutter may need no more than a small supply from a drip-can, whereas, on the same machine, the operation of a gang of cutters for deep roughing cuts will require a large stream to flood the work thoroughly and wash the chips away. Some machine tools, such as brass-finishers' machines of many types, cylinder-boring machines, some lathes for machining castings only, and some

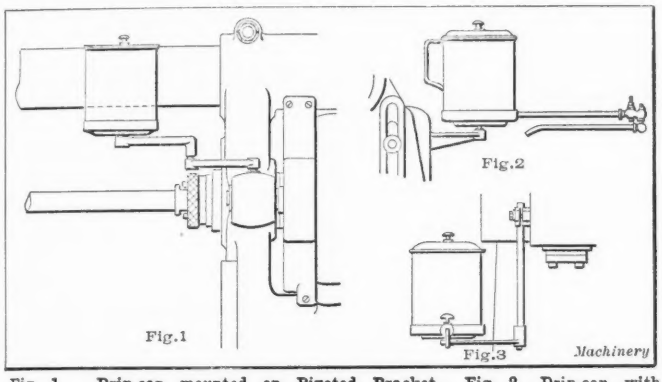

Fig. 1. Drip-can mounted on Pivoted Bracket. Fig. 2. Drip-can with Jointed Delivery Pipe. Fig. 3. Drip-can arranged for Vertical Adjustment

of the reciprocating types of machines for brass or cast iron only, have no arrangements for lubrication of the tools. In many, a compromise is made so that the addition of a lubricating system is easily effected. In order to avoid a multiplicity of designs, some firms build certain of their machines with the channels, trays, etc., essential to the flooded system, and omit or supply the pump and piping as wanted.

The Amount of Lubricant

There are three principal reasons for the adoption of a lubricating system: One is to cool the tool or cutter, another

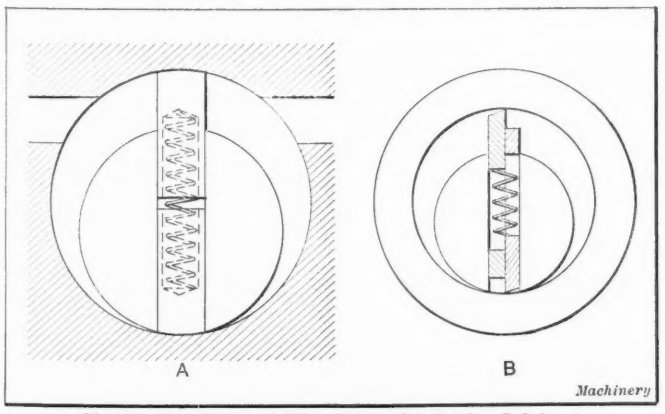

Fig. 4. Two Types of Wing Pumps for Cutting Lubricant

to impart a smooth surface to the work, the third to wash away the chips. The first-named is frequently the only reason for the application of a lubricant. For instance, in many operations on brass and other alloys the surfaces would be tooled just as smoothly without the lubricant, but the tools would heat up, and the work would also become too warm if the operation were long-continued; hence the accuracy would be impaired, while the cutting edges would not endure for a sufficient length of time. On the other hand, drilling, particularly in deep holes, sometimes cannot be done at all unless the lubricant is fed with sufficient force to eject the chips as fast as they form. A quantity much in excess of the requirements for cooling alone is therefore required.

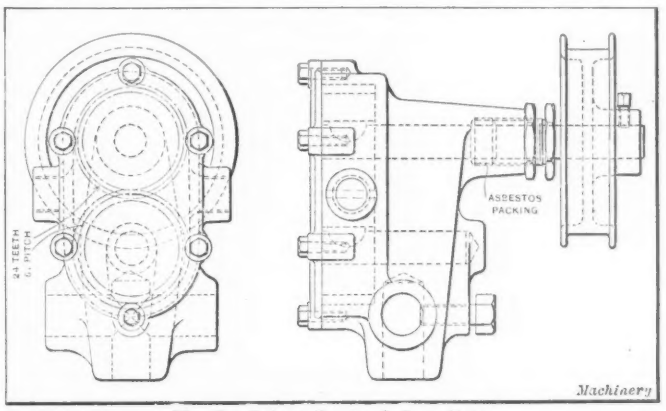

Fig. 5. Rotary Pump of Gear Type

When a metal or alloy cannot be tooled with a smooth finish unless lubricant is employed, it may not be necessary to use a large quantity, so long as the edges of the tool and the portion of the work adjacent thereto are covered. The necessity for an increased supply soon arises, however, as speeds and feeds are increased; otherwise the film of lubricant will be too attenuated to spread as fast as the metal is cut into, and the result will be that intervals of dry cutting will occur, and the heat will evaporate the film to such an extent that it becomes useless. A further development is reached when the heat, caused by cutting, raises the temperature of the cooling medium to such an extent that the latter ceases to act effectually. This happens when the total amount of

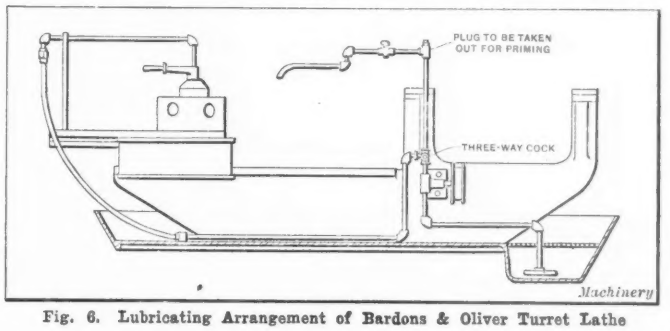

Fig. 6. Lubricating Arrangement of Bardons & Oliver Turret Lathe

liquid is not large enough to provide for cooling in the intervals between successive applications to the cutting tool. The remedy is a much larger amount of liquid, and preferably a return tray of ample surface area, so that the maximum amount of area shall be exposed to the air. In extreme instances, two tanks may be utilized, each holding a large body of lubricant, which are drawn from alternately, thus affording intervals for each to cool somewhat.

The essentials involved in any system of lubrication are the supply, collection and separation from cuttings, and method of return. The first two requirements include many devices and modifications, ranging from the time-honored drip-can to elaborate pump and piping arrangements, and from a simple can hung beneath a table to a complete series of rims, chutes, troughs, pipes and strainers. The distinction between the two extremes is due to the quantity of lubricant required, since a simple system that is capable of feeding and collecting a few pints of liquid used at a slow rate is totally inadequate for the flooding method; neither is it automatic in action but necessitates frequent attention.

The amount and nature of the chips also materially affects the mode of collection and one method is not suitable for

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all cases. Large curling chips, and fine swarf (such as from a hacksaw) are very different as regards the separation of the lubricant from them, the swarf being much more difficult to separate. The bulk of the chips is also important in considering the method of collection and separation. If they occur in small quantities, very little extra accommodation beyond that necessitated by the liquid is wanted, but if there is a large bulk of chips to be received, the sizes of pans and trays must be varied accordingly and supplementary boxes or trays on wheels are essential for frequent removal.

Drip-can Method of Supplying Lubricant

Various methods of supply and collection are illustrated in connection with this article by drawings of various machines, but these are only a fraction of the immense number of modifications which exist in practice. The drip-can is the oldest form of continuous supply and is still employed extensively for operations where its limited feed is suitable and sufficient. It is often included on machines which have a pump outfit as well, for use when the ample flow provided by a pump is unnecessary, the can being preferred when the class of work for which it is suited has to be done for a considerable time. The usual design is that of a cylindrical vessel, preferably with a cover, and an inside strainer of gauze (unless the liquid is strained previously). The can body is made of either sheet metal or cast iron. If the capacity of a cylindrical can is insufficient, a rectangular tank is sometimes used instead, as on some shafting lathes with multiple rests. Variations occur in the manner of holding the can, and the position and number of outlets. As a can, in most cases, is placed quite close to the point of application of the liquid, a short pipe is all that is necessary; this may be single- or double-jointed, to bring the spout to the location desired. The can is either placed upon a flanged tray, supported upon a pillar fixed in any convenient position, or it is held either by a band, or stem and wing-nut on a slotted arm beneath, to permit of radial or vertical adjustment. The vertical adjustment is not of so much importance because the lubricant can be directed to fall on the work, but considerable adjustment in a horizontal direction is desirable, especially in machines where the cutters or tools occupy varied positions. Figs. 1, 2 and 3 illustrate common methods of adjustment. Fig. 1 shows pivoted arms, on the outer one of which the can is held; Fig. 2, a fixed bracket with jointed pipe, which gives much the same result; and Fig. 3, a suspension rod. The latter is employed on vertical milling machines, etc., to permit radial and vertical adjustments.

When the construction of a machine will not permit placing a can close to the tool, use is often made of flexible tubing of rubber or metal for connecting the can and spout.

Pumps for Cutting-tool Lubricating Systems

The drip-can ceases to meet requirements when the quantity of lubricant that must be delivered exhausts the contents of the can in a few moments. A pump which is automatic and under the control of the attendant, is then the only method of providing a sufficient supply. Four types of pumps are in use: Centrifugal, plunger, wing, and geared, the latter being in the majority. The centrifugal pump is not used to any great extent but is sometimes preferable when there is grit in the lubricant. The plunger pump is employed only to a limited extent, although in the early days it was probably the only kind used for supplying drills and boring tools for deep-hole work in lathes. Where a large supply is desired or where the parts of the machine run at such a slow speed that there is no opportunity for drawing a rotary pump at a proper speed, the plunger type is still used, the most notable example being that of certain bolt-threading machines.

The construction of the wing type of pump comprises a casing with a chamber bored eccentrically (see Fig. 4)

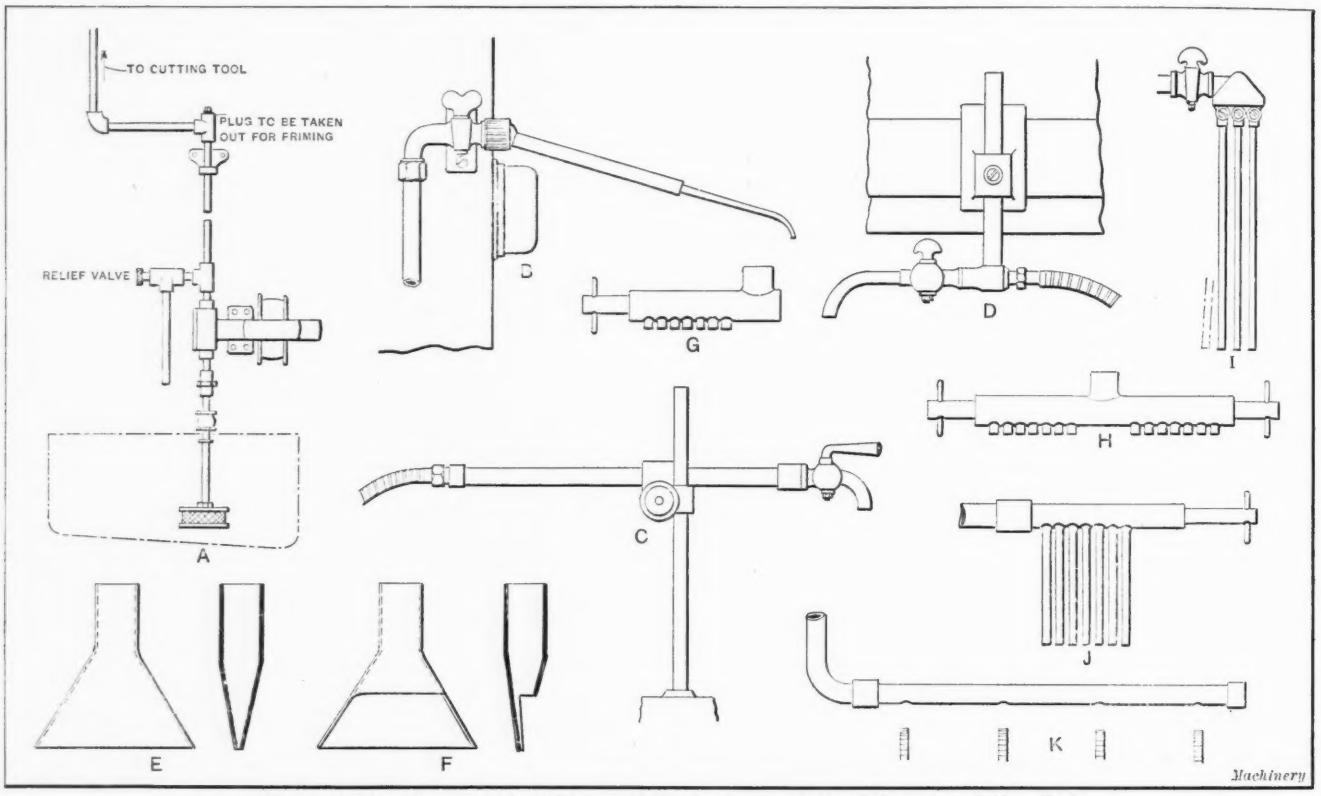

Fig. 7. Various Arrangements of Piping and Nozzles for distributing Lubricant to Cutting Tools

with relation to the spindle bearing. The enlarged head of the spindle is slotted to receive a pair of flat plates or wings, pressed apart by a brass spring or springs, so that as the spindle rotates, the ends of the plates maintain contact all around inside the chamber, thus drawing the liquid in and discharging it in one direction or the other according to the way in which the spindle rotates. These pumps will lift the lubricant a slight distance, but it is better to submerge them to avoid priming. A modification of the ordinary method of making the wings as illustrated at *A*, is shown at *B*. The latter type is manufactured by Messrs. C. Wicksteed & Co., Ltd., of Kettering (England) for use with their hacksawing machines. The wings, instead of meeting at the center, are thinner and pass right through the spindle head. Slots are cut in each section, as shown, so that a single spring presses the halves apart equally. The wings are tapered at the ends so that when a full discharge is not required, the pressure of the liquid will press the wings back. This renders the use of a relief or overflow valve unnecessary.

The geared pump, a type employed to a far greater extent than any other, is of simpler construction, the essential parts being a pair of spur gears revolving inside a closely

fitting case and drawing the liquid around in the tooth spaces. This type has no delicate parts to get out of order, and if properly built, enables high pressures—up to 1000 pounds per square inch—to be obtained. These high pressures are, of course, not necessary for feeding to external cutting tools, but for deep-hole drilling, in which great force is necessary to remove the chips, they are utilized. The low pressure pumps work to 100 pounds per square inch or less. For the average machine, it is merely necessary to raise the liquid and overcome the friction in the pipes and distributor; any surplus pressure is only useful for washing away chips, the need for which varies with the class of operation. Some kinds of chips fall naturally out of the way whereas others tend to clog the work and the cutters. Some materials will stick to the cutters or work if lubricated to a moderate extent, and may require a larger stream and greater pressure to dislodge them. The removal of long curling chips, especially heavy ones, is not facilitated by the force of the stream, unless they are forced out of a hole.

The geared pump, an example of which is seen in Fig. 5, is rated to deliver a certain quantity at a definite number of revolutions per minute, and it may be run at higher or lower speeds if desired, with a varying output. The pump shown is made by Messrs. H. W. Ward & Co., Ltd., of Birmingham, (England). In place of the usual foot, it has holes to slip over a piece of shaft secured to the machine in any convenient location. This permits of setting the pump in three different positions, according to the belt location. The following table gives the capacities of two sizes of Brown & Sharpe geared pumps, with driving pulleys of 3½ inches and 5 inches diameter, respectively:

	Revs. per Min.	Capacity, Quarts per Min.	Suction	Discharge
No. 1	300	4	⅜ inch	¼ inch or ⅜ inch
	500	8		
No. 3	300	20	¾ inch	½ inch or ¾ inch
	500	40		

The lift ranges up to 20 feet, but it is preferable to put the pump as near the level of the tank as it convenient, the exact location depending upon the type of machine and the facilities for attachment to the side of the framing or the edge of the tank or pan. The method of driving depends partly upon the position of the pump and partly upon the designer's ideas. The belt or cord drive is the most common. Spur gearing and chains are also used to a lesser extent, the advantage of these being that there is no bother with slipping belts nor trouble due to the splashing of oil. It is often more convenient to drive the pump by gears or chain from some constant-speed shaft on the machine, than

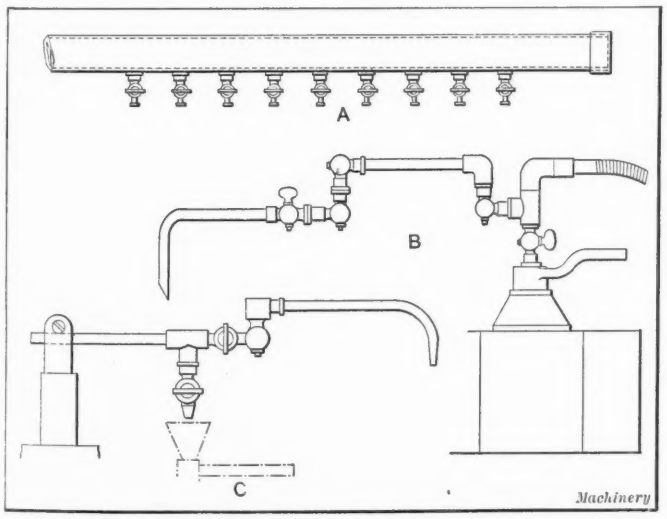

Fig. 8. A. Distributor with Row of Taps. B. Combined Supply Pipe for Interior of Turret and External Tools. C. Supply Pipe feeding into Funnel on Box-tool

by a belt from the countershaft; when a motor drive is installed, the gear or chain method is especially applicable. The pump is thrown out when necessary, by sliding the gears out of mesh or by disengaging a clutch, if a chain is used. Generally, pumps run in one direction, provision being made to drive them from a shaft or countershaft which does not reverse, but when the machine reverses at intervals, as with certain automatic screw machines, the pump is slightly modified to enable it to run in either direction.

The fittings which are directly connected with the pump system include a strainer, which is submerged in the liquid and prevents access of grit or chips, and a relief valve, which is closed by spring pressure but opens when the flow is reduced or stopped at the delivery outlet, allowing the lubricant to run back to the tank through a by-pass. Sometimes a check valve is placed between the pump and the tank, but not invariably. Fig. 6 shows the piping for a Bardons & Oliver turret lathe, including a flexible supply pipe to the turret center for feeding hollow tools, and the diagram *A*, Fig. 7, shows the piping for a Brown & Sharpe milling machine. These two views represent, in principle, the arrangement of many machines. A pump for each unit is dispensed with in certain cases, as, for example, "batteries" of automatics or of sensitive drills, which are fed from a common supply instead of having a pump for each machine.

Methods of Distribution

The two points which we now have to consider are: (1) The means of distributing the lubricant to the tool or tools;

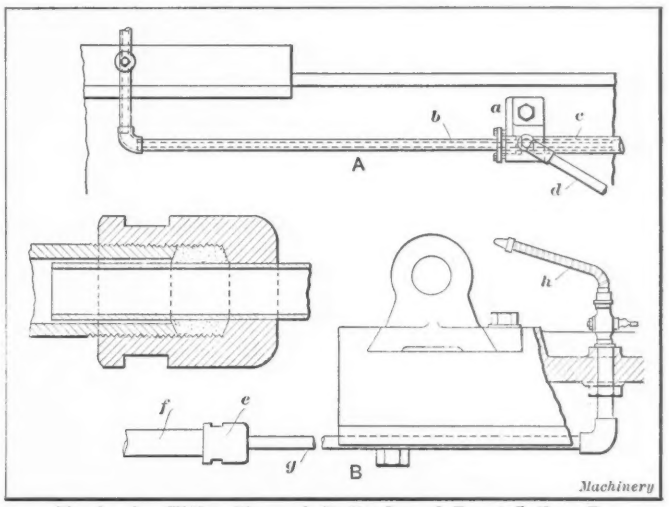

Fig. 9. A. Sliding Pipe and Stuffing-box of Turret Lathe. B. Telescopic Pipe Connection for Carriage of Gear-cutting Machine

and (2) the means for catching the lubricant and returning it to the tank. The methods of distributing and returning the lubricant vary greatly on account of the varying conditions of cutting and different arrangements of tools, slides, machine framings, etc.

In regard to the method of distribution, the choice lies between rigid pipes, flexible pipes, and jointed pipes; between a single outlet, two or more outlets, a perforated distributor, a pipe with a number of taps or pipes leading from it, or an overhead reservoir fitted with outlet pipes. Means may be provided in the case of multiple outlets to shut off any or all of these according to the amount of lubricant desired and its place of delivery. The flow may be allowed to fall from above, or it may be directed precisely to a certain spot by a pipe, or through a hollow tool or spindle, or a spout or chute may catch the lubricant and pour it onto a precise location.

Rigid pipes are chiefly applicable to machines which have no great changes of tools or adjustments of slides, so that a fixed position of the pipes is suitable, but these are the exception, and it is better to have an adjustable pipe, for convenience in moving it out of the way if necessary. The degree of movement depends on the range of possible locations of the cutting tools. Piping with three or four joints is frequently necessary, including horizontal and vertical swivel adjustments. The alternative is the flexible pipe, which however, is likely to be in the way in many instances. A flexible pipe is more useful as a means of connecting rigid or jointed pipes to the supply or drawing-off arrangements.

A single outlet is all that is necessary for most of the single-point cutting tools, for narrow milling cutters, drills, and similar tools, but two or more outlets are required for pairs or gangs of cutters and multiple tools, unless the

alternative of a single wide spout is utilized. The main support of a jointed pipe is placed according to circumstances, sometimes consisting of the supply pipe itself, sometimes of a separate rod to which it is attached, the rod being bolted or screwed in any convenient position. The main pipe or rod must be put where it is not likely to be in the way of large work, jigs or fixtures; in some cases, a portable fitting may be necessary to meet these requirements. An alternative to the gas-bracket type of jointed pipe is one having a ball-joint and telescopic second tube (see *B*, Fig. 7).

A preferable method of securing flexibility is to use a short piece of pipe equipped with a tap, and hold this in a clip against a part of the machine or on a rod, and connect to the pump with flexible tubing. This arrangement is useful when no great range of adjustability is essential and also when considerable horizontal or vertical range is required. In the first case, it obviates the use of a jointed pipe, and in the second it enables adjustments of several feet to be obtained without encumbering the tool with three or four jointed pipes. Typical examples are shown at *C* and *D*, Fig. 7, *C* showing a rigid pipe held by a split clamp to a rod screwed into a machine boss and connected to a flexible tube, and *D* a stem extending from the connection and clamped in a bracket horizontally adjustable along a slide. As the flexible pipe can be carried down at the rear or side of the machine, it need not interfere with the operation of the machine; moreover, if cutting is done without lubricant, the clamps may be released and the piping laid out of the way altogether. Arbor supports or overhanging arms on the machine are often used for attaching pipe clamps.

A cutter of considerable width, or a hob, must have an ample supply of lubricant along its entire length, if lubrication is to be effective and even, and cooling uniform. A good device for hobs and cutters for heavy duty is the fan nozzle. This is set vertically, or at an angle, just above the cutter, and delivers a broad copious stream. The closed type *E*, Fig. 7, is employed in the case of slab millers having the cross-slide face set at an angle, the nozzle being pointed inward or toward the back of the machine. The partly open kind *F*, is suitable for horizontal delivery or delivery at a slight angle. These nozzles are attached to the delivery pipe, but in a few instances the nozzle is used separately, being clamped to a part of the machine or to the tool itself and fed by a flexible pipe brought over it, thus affording a wide stream without modifying the outlet for ordinary operations.

Adjustment for width of flow is provided for in some nozzles, the opening being blocked to any desired extent by sliding a plug along to suit the width of the cutter. When there is no adjustment to the supply pipe to accommodate the varying lateral positions of cutters on their arbors, the nozzles may be pointed to right or left, as desired, by fitting it with a swivel joint. Perforated distributing pipes which give a flow of lubricant to suit the length of work or cutter are shown at *G*, *H* and *J*, Fig. 7. They have sliding plugs to shut off some of the holes, thus reducing the supply. Pipe *G* is an ordinary form, *H* is double-ended (a type useful for gang mills on an arbor which is steadied by a central support) and *J* has extension tubes hanging down to reach in between tools which interfere during part of their stroke, with a directly vertical flow. This type of distributor is also used where the air from a belt or other rapidly moving part would disturb the vertical stream of lubricant and blow it out of its proper path. At *I* the tubes are pivoted to swivel to one side and direct the liquid to a particular place. A shut-off may or may not be provided for each tube.

The standard distributing pipes occasionally fail to meet special conditions, and it becomes necessary to cut a piece of tubing and drill it specially, as at *K*, where four slitting saws are set rather far apart and a pipe is drilled with holes to suit. If much of this class of work is likely to be done, it may be preferable to drill a larger number of holes in the pipe and plug up those not wanted. Long distributing pipes are sometimes provided with holes drilled fairly close together and having spring bands which are partly rotated to block those holes which are not required. Another special arrangement for some classes of work where a guard is fitted over the cutters is to use the hollow top of the guard for conducting the lubricant directly upon the cutters. Box-tools are also sometimes made with hollow frames, with an outlet close to the cutters, giving a broad stream at the best possible location. This is a mode of distribution that must be designed to suit the tools, and is not of general application.

An alternative to the practice of stopping off or plugging up unused holes in a distributing pipe, is to provide regular taps for turning off the lubricant. This method is common to slab or "plano-millers" on which a pipe of ample capacity is secured to the cross-rail and has a number of taps screwed in at close intervals, as shown at *A*, Fig. 8. If the pipe runs along at the back of a machine or below a cross-rail, as in many multiple-spindle drilling machines, pipes connected to each tap will be essential in order to bring the oil to the drills, a swivel-joint permitting each pipe to be placed in the position desired.

The case of two or more pipes having outlets separated more widely than in the distributors referred to, is often met with, such as when two tools or cutters are working on different parts of a piece or on two pieces of work. Either rigid or swiveling pipes are used, according to requirements, or provision for variation between the outlets is made by a length of flexible pipe. Certain multi-spindle drilling machines and multi-spindle automatic screw machines carry a pipe partly around the spindles or around the turret, and various bent pipes or distributors lead off from this common supply pipe to feed each drill or turret tool. At *B*, Fig. 8, is an example of a double supply, one pipe leading to the center of the turret for lubricating hollow tools, and the other continuing for feeding external tools held in the turret. A somewhat similar arrangement is shown at *C*; the tap nearest the turret feeds into a funnel which is connected to a slot distributor attached to one of the box-tools having a long cutter for forming steel taper pins; this arrangement insures a proper flow all along the broad-faced cutter.

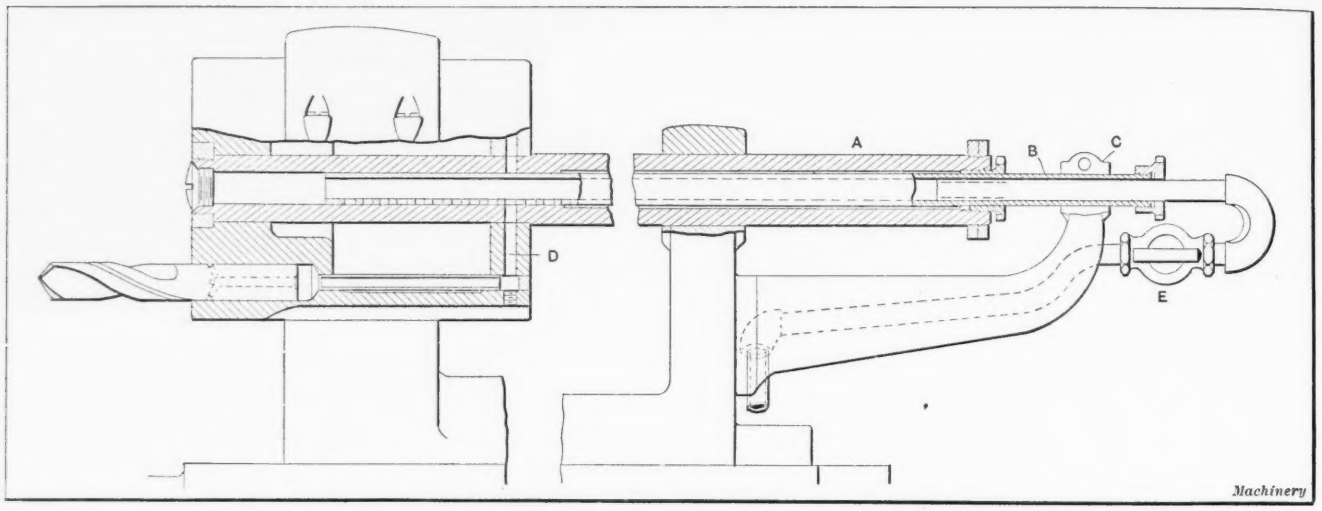

Fig. 10. Sectional View showing Method of supplying Oil to Turret of Cleveland Automatic

Portions of machines which move intermittently or continuously along a bed, and must be fed with lubricant in any position they occupy, require the use either of jointed pipes, flexible connections, or telescopic tubes. Both of the latter are used largely. The flexible tubes are likely to get in the way and become a nuisance, while the telescopic pipes can be arranged in snug fashion and occupy a minimum of space; moreover, they are not as liable to become damaged as flexible tubes. It is chiefly in those types of machines where the tool has a horizontal feeding movement, that the provision of adjustable piping is required. Gear-cutting machines and turret lathes are the most frequent examples, the cutter-slide of the one, and the turret-slide of the other requiring a supply of lubricant at all working positions. Certain other machines of less importance in point of numbers, such as horizontal drilling machines and slot-drills with traveling cutter-heads, also require adjustable piping. The telescopic device *A*, Fig. 9, which also shows the back of a turret lathe with a portion of the turret saddle, has a fixed bracket *a*, fitted with a stuffing-box through which the sliding pipe *b* is free to move. The latter passes into the closed end of pipe *c*, which is fed by the pipe *d*, from the pump.

Connection to the sliding cutter-carriage of a gear-cutting machine is made either by the somewhat clumsy means of a flexible pipe, or by a sliding pipe which is arranged, preferably, below the base, as at *B*. (From the practice of Messrs. J. Parkinson & Son, Shipley, Yorkshire.) The packed gland *e* (shown enlarged in section above) is screwed on the end of the stationary pipe *f*, and admits the sliding pipe *g*, which is united to a short vertical pipe fixed to the cutter-carriage. From this vertical pipe the short length of flexible steel tube *h*, directs the stream onto the cutter.

Another system of distribution for movable parts is that requiring a supply to tools in a turret, one or perhaps two or more of which may require the lubricant to be fed through their hollow bodies during their period of operation only. This is effected by causing the rotation of the turret to turn on and cut off the oil as the tools come into their working position. The arrangement for the Cleveland automatic screw machines is shown in Fig. 10, and will serve to illustrate the principle. The feed takes place when the drill shown is at the lowest or working position. The turret shaft *A*, in its to-and-fro movements, controls the feed in the following manner: An oil tube *B* extends inside the shaft and can be clamped in the bracket *C*, wherever desired. This tube has a series of holes in its lower side, continuing for a distance equal to the turret stroke. These holes communicate with a single hole *D* connecting with a tube inserted in the turret hole which carries the tool. The position of tube *B* determines when the oil will begin to flow; it can be adjusted to start at the beginning of the stroke, or later. Valve *E* is to regulate or shut off the oil. Can action is employed in some machines to turn the oil on and off.

BUILT-UP UNIVERSAL GEAR PATTERNS

One of the problems confronting a manufacturer of gears, especially when he makes a practice of furnishing gears of all shapes, types and sizes, is the tying up of a large amount of his capital in patterns. Of course, it is evident that where the sizes are close to some standard, slight alterations can be made in the mold before the gear is cast, but where the difference exceeds limits greater than those which can be handled in this manner it is necessary to make a pattern in each case.

The Foote Gear & Machine Co., Chicago, Ill., has worked out a system of built-up interchangeable patterns which reduces the number of patterns made to a minimum. These patterns are built up from a number of standard parts, and as shown in Figs. 1 and 2 the only part common to all is the center *A*. This center portion is made from a cast-iron shell to prevent the pattern from being wrecked in the foundry, and is arranged with projecting bosses, equal in number to the arms required in the gear. In these projections the removable arms *B* are held, simply being pointed and driven in place and then fastened by screws. The arms can be procured in strips machined to the required shape and it is only necessary for the patternmaker to cut them off to the required lengths. The rim *C* of the pattern is made from two circular members consisting of segments which are provided with holes clear through. These holes are formed by the halves of each groove in the circular segments, which are parted at the center so that the arms can stick out, thus enabling gears of various outside diameters to be cast from the same pattern by simply shifting the position of the rim on the arms. Six inches is about the maximum projection that can be allowed without interfering with molding. The hub of the gear pattern consists of two circular blocks which have projecting bosses that fit in the hole in the center portion of the pattern. The core prints *E* are then screwed to the built-up hubs, and the pattern is complete.

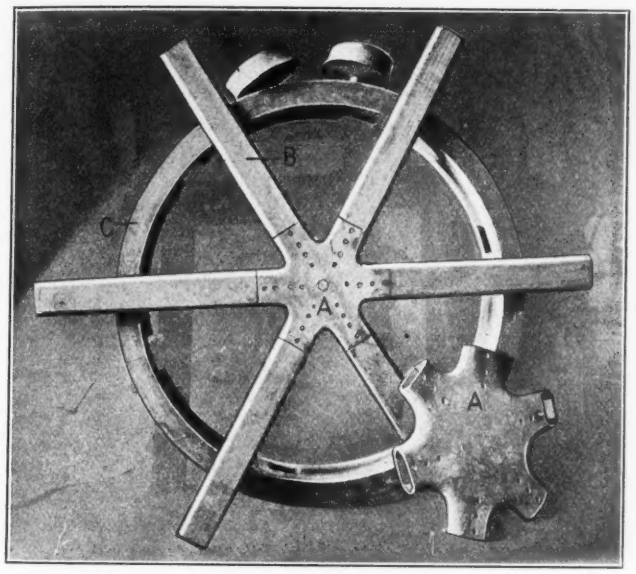

Fig. 1. Component Parts of Built-up Universal Gear Pattern

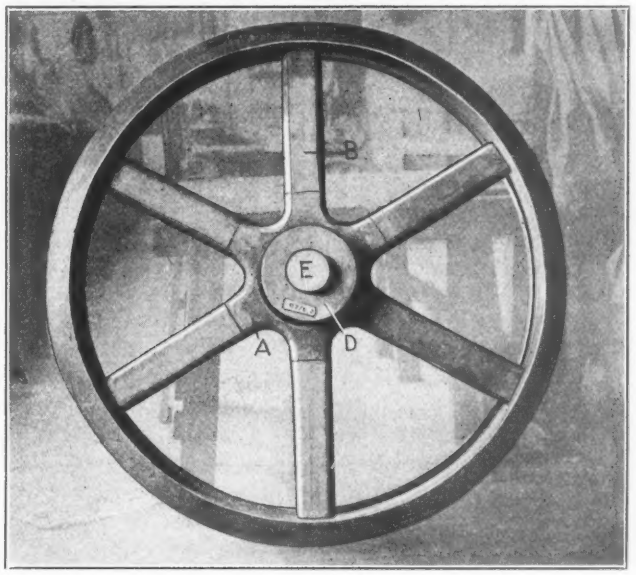

Fig. 2. Pattern assembled and ready for use

This standard pattern, by the addition of the built-up portion previously mentioned, can be used for practically any special gear that comes into the plant, and the number of parts are so few that the problem of storing is greatly simplified. When an order comes in for a gear for which no pattern is made up, it is only necessary for the patternmaker to look through his stock of hubs, rims, arms, etc., and pick out those which approximate the requirements. This not only makes it possible for the manufacturer to produce a cheaper gear, especially when ordered in small lots, but it also enables him to fill the order much more quickly than if it were necessary for him to make up a pattern for each size of gear.

D. T. H.

* * *

A lining for plating tanks, to protect them from the influence of acids, is made from a mixture consisting of 75 parts, by weight, of pitch; 9 parts plaster-of-paris; 9 parts ocher; 15 parts beeswax, and 3 parts litharge.

AN EFFICIENT FILING SYSTEM FOR THE DRAFTING ROOM

BY G. E. CAMPBELL*

Considering the number of questions the engineering department is called upon to answer daily, and the numerous drawings which have to be referred to in order to give correct information, the necessity of an efficient system for filing drawings and keeping a record of blueprints that are

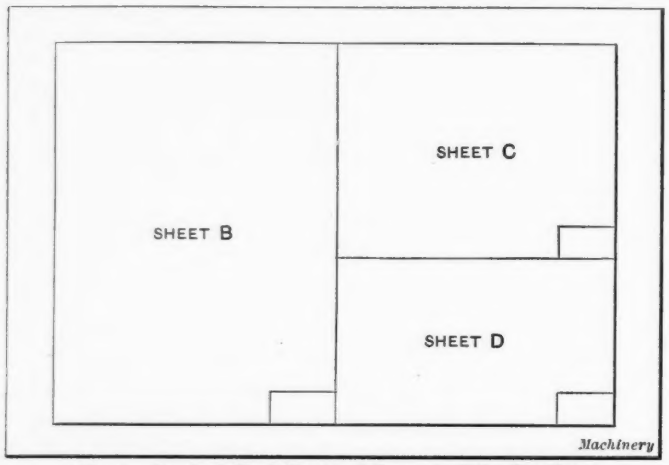

Fig. 1. Standard Sized Sheets of Paper used for Drawings

given out is apparent. In this day when sectional filing cabinets with drawers of convenient size can be bought ready for use, it is possible for a drafting-room of any size to have a first-class and efficient filing system which will enable the draftsman to find any drawings in the room immediately and keep a complete record of all blueprints given out. The system which the writer is about to describe has been installed in two different manufacturing plants and both are pleased with the results obtained.

Size of Drawings

The first thing necessary is to adopt standard sized sheets for drawings, and these sizes will depend upon the material used in making the drawings. As a general proposition, it

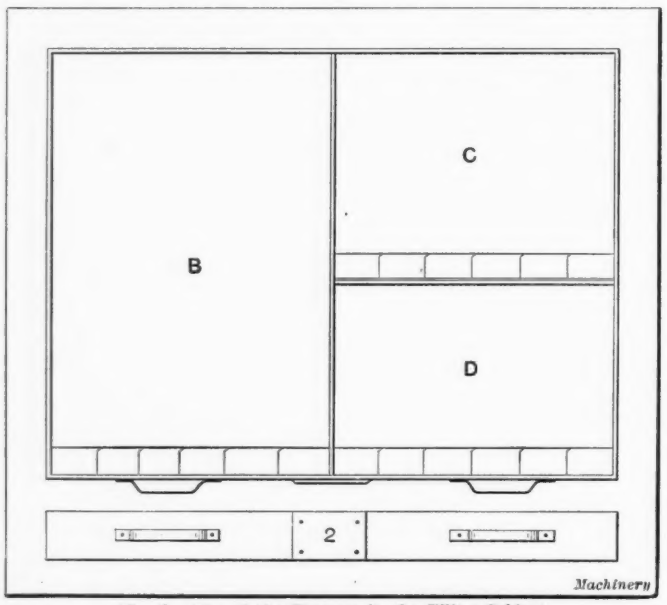

Fig. 2. One of the Drawers in the Filing Cabinet

is preferable to make new drawings on Crane's No. 25 bond paper, as they can be inked directly on this paper, thereby saving considerable time and avoiding the mistakes made in tracing drawings. This quality of paper also makes excellent blueprints. Paper without the "water mark" comes in sheets 27 by 40 inches in size and this will be known as sheet *A*. By cutting the sheet in the center, two sheets 27 by 20 inches in size are made, and each of these will be known as sheet *B*. Again cutting sheet *B* we get sheets *C*, 15 by 20, and *D*, 12 by 20 inches in size. Every sheet has a title in the lower right-hand corner, as shown in Fig. 1, and if the inside measurements of the drawers in filing cases are 31 by 41 inches there will be just enough room for partitions between the different sized sheets.

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The System

Let us suppose a line of standard machines of different sizes is being manufactured and that each machine requires drawings of the different sizes previously mentioned. It is very convenient to have all the drawings of each machine filed together, and in order to do this, each drawer in the filing cabinet should be provided with partitions of heavy manilla paper or light cardboard. Those partitions should have tabs bearing the name of the machine contained therein, as illustrated in Fig. 2. The drawers are then numbered consecutively on the front.

Numbering the Drawings

Each drawing bears a number just under the title and this number consists of a letter denoting size of sheet, number of drawer in which sheet is filed, and number of sheet in the drawer. For instance, the number *B* 232 means that the sheet is size *B*, or 27 by 20 inches, that it is filed in drawer

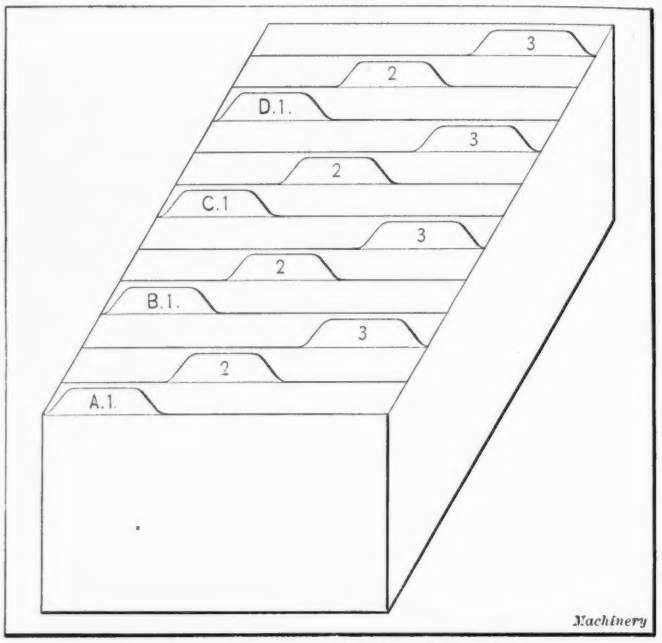


Fig. 3. The Numerical Index of Drawings

No. 2 and is the thirty-second drawing filed in this drawer. It will be filed under the tab bearing the name of the machine for which the drawing was made. If the drawing happens to be a detail drawing of a part used on more than one machine, blueprints are made and marked "Record Prints," and these prints are filed under the tab for the machine

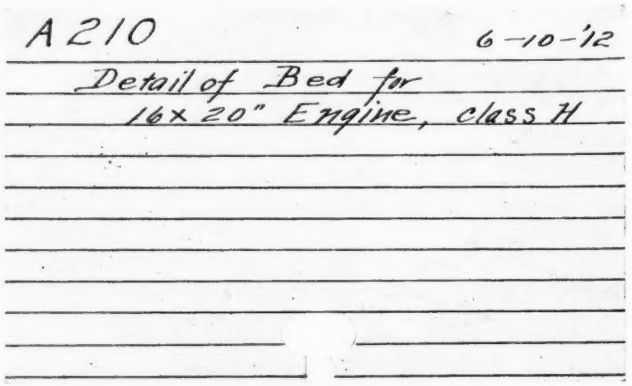


Fig. 4. Card used in the Numerical Index

intended. In this way, a complete set of drawings for each machine is always at hand and filed together for ready reference.

The Card System

As a check against mistakes, and to complete the record, three sets of cards are kept, each under a different head, *viz.*,

"Numerical Index," "Machine Index" and "Customer's Index." The numerical index cards should be made before drawings are filed and the finished index will appear as shown in Fig. 3.

One of the individual cards is shown in Fig. 4. This card would be filed in section *A* after 2, and by numbering these cards consecutively and in advance there is no danger of having the same number on any two drawings, as this index must be referred to before numbering a drawing. For example, a size *A* drawing for drawer 2 is to be numbered, and

Engine 16"x20" Class H.

No.	Side Crank, Balanced Valve	
A210	Bed, Detail	6-10-12
B208	Cylinder, Detail	6-20-12
C240	Valve, Detail	6-20-12
D240	Crank, Detail	7-2-12

Fig. 5. Card used in the Machine Index

by referring to index under *A* 2 we see that *A* 210 is the last number used; therefore we use blank card *A* 211 and put this number on the drawing. The title of the drawing is also written on this card. Frequently only the number of the drawing is referred to and in order to locate and identify the drawing, this index is very valuable.

The machine index is simply an index bearing the name of machines alphabetically arranged, the cards being ruled as shown in Fig. 5. The advantage of this card is chiefly as a check, and when all of the drawings for a machine are wanted, it is well to refer to this card for the complete list, as there is always a chance of someone putting a drawing away in the wrong place. By referring to the card, you

Smith Mfg. Co.

No.	New York	Mailed 6-10-13
B340	Erecting Plan of Boring Mill	
C331	Detail of Housing for Boring Mill	
A210	Detail of Bed for 16"x20" Engine	

Fig. 6. Card used in the Customer's Index

know that you have a complete set of drawings. It is also handy for the man getting up a complete set of blueprints for a machine.

The customer's index is a record of blueprints mailed to the customer. The cards are ruled as shown in Fig. 6 and are filed in an index which is arranged with the customers' names in alphabetical order. This will be found valuable in order to locate the exact blueprint mailed to a customer.

* * *

Effective ventilation means first of all that the air in a room is kept in motion. It does not necessarily mean that the air is being rapidly displaced by the outer atmosphere. Workmen will be comfortable in a warm shop if the air is kept in motion so that a perceptible breeze is felt. To merely change the air is not enough. For this reason, it is a mistake to design a shop, especially a blacksmith shop, with the window openings six or seven feet above the floor. At this height, the direct effect of the air coming in is not felt by the men, who, as a result, are likely to suffer severely, notwithstanding the fact that the air is constantly changing. They do not feel the breezes and the drying of perspiration is slow.

STRESSES IN BRICK PRESS MOLD BOXES

BY SAMUEL B. KANOWITZ*

In the design of mold boxes for repressing clay products to their required form, designers have not had any rational formula to follow, since the stresses transmitted to the frame vary with the plasticity of the clay. As the writer has had occasion to use various sized mold boxes, the following formulas were developed, the coefficients given having been derived from experimental tests. For all practical purposes, we may consider that each side of the frame of the mold box (see Fig. 1) is subjected to two stresses—one a bending stress due to the distributed load acting on the side direct, and the other a tensile stress due to the reactions of the adjacent ends, as shown in Fig. 2.

The bending stress can be found from the formula for a uniformly loaded beam fixed at the ends, or

$$p_1 = \frac{Pl}{12Z} \qquad (1)$$

where p_1 = stress per square inch;
P = total load on beam;
l = length of beam;
Z = section modulus.

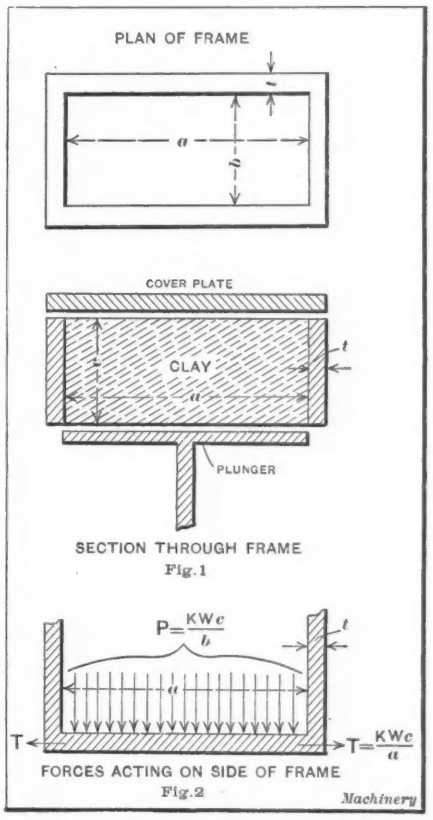
In the case under consideration let
W = total upward force of plunger;
a = inside length of frame;
b = inside width of frame;
c = depth of frame;
t = thickness of metal.

In the case of a fluid where the pressure is distributed uniformly in all directions, we have the following formula;

$$p_2 = \frac{W}{ab} \qquad (2)$$

where p_2 = pressure per square inch in all directions.

In dealing with a clay, however, we find that the pressure is not distributed equally in all directions and that the unit pressure on sides and ends can best be expressed by the following formula



Diagrams illustrating Brick Press Molds

$$p_2 = \frac{KW}{ab} \qquad (3)$$

In this formula, K is a constant depending on the nature of the clay and amount of moisture in the material to be repressed. The following values of constant K were obtained from experiments on brick at different stages of drying:

Nature of Material	Percentage of Moisture				
	10	15	25	35	50
	Values of K				
Soft plastic clay	0.68	0.73	0.82	0.90	0.94
Medium plastic clay....	0.62	0.68	0.78	0.85	0.90
Coarse plastic clay	0.58	0.65	0.76	0.84	0.90
Fireclay, kaolin.....	0.50	0.55	0.64	0.72	0.80

The area of side A of the frame = ac (see Fig. 1); there-

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fore, the total load on side A equals $\frac{KW}{ab} \times ac$, or,

$$P = \frac{KWc}{b} \tag{4}$$

The section modulus of side A about the neutral axis is equal to $Z = \frac{1}{6} ct^2$. Substituting the values of P and Z in Equation (1) and noting that $l = a$, we have the following result:

$$p_1 = \frac{KWa}{2\,bt^2} \tag{5}$$

From this equation we note that the bending stress varies with values a, b and t but is independent of the values c.

The tensile stress on side A is due to the outward pull exerted upon it by the load on the two adjacent ends. The area of each of these equals $b \times c$, and the load per square inch from Equation (3) equals $\frac{KW}{ab}$; therefore, the total load on each end equals $\frac{KW}{ab} \times bc = \frac{KWc}{a}$ or, calling the tensile force that pulls on side A, T, then

$$T = \frac{KWc}{a} \tag{6}$$

The area over which T acts equals $c \times t$; therefore, we have

$$p_2 = \frac{T}{tc} = \frac{KWc}{atc} = \frac{KW}{at} \tag{7}$$

where p_2 = the direct tensile stress.

Combining Equations (5) and (7) we obtain

$$p = p_2 + p_1 = \frac{KWa}{2\,bt^2} + \frac{KW}{at} \tag{8a}$$

where p = the resultant stress in the frame due to flexure and tension. Equation (8a) can be reduced to the following form:

$$p = \frac{KW}{ab}\left(\frac{a^2 + 2\,bt}{2\,t^2}\right) \tag{8}$$

In designing a frame, the combined stress in the longer side only is considered, since the combined stress in the longer side is greater than the combined stress in the shorter side. The bending stress in the longer side is also greater than the bending stress in the shorter side, since their ratio is, from Equation (5),

$$\frac{KWa}{2bt^2} \div \frac{KWb}{2at^2} = \frac{a^2}{b^2}$$

Although the tensile stress in the shorter side is greater than the tensile stress in the longer side, still their ratio is, from Equation (7),

$$\frac{KW}{bt} \div \frac{KW}{at} = \frac{a}{b}$$

From the above equations, we see that the ratio of the bending stresses in the longer to the shorter side, varies as the square of $\frac{a}{b}$, while the ratio of the tensile stress in the smaller to the longer side, varies as the first power only, so that the sum of the combined stresses in the longer side is greater than the sum of the combined stresses in the shorter side.

Solving Equation (8) for t we obtain

$$t = \frac{KW}{2\,ap} + \sqrt{\left(\frac{KW}{2\,ap}\right)^2 + \frac{KWa}{2\,pb}} \tag{9}$$

In the above equation, if a is much longer than b, the quantity $\frac{KW}{2\,ap}$ can be neglected and Equation (9) reduced to the following form:

$$t = \sqrt{\frac{KWa}{2pb}} \tag{10}$$

This same result can be obtained by solving Equation (5) for t, thus showing that under the above conditions, the tensile stress can be neglected in comparison with the bending stress.

The data given in the foregoing is applicable not only to ordinary hand and power re-presses, but also to brick-forming machinery such as soft-mud machines and dry-press machines; in the latter type, the forces required are enormous. The question of brick machinery design and installation has been very much neglected, due particularly to the general inefficiency of the average brick plant but, principally, because the average brick machinery designer has a very meager knowledge of clays and depends mostly upon guesswork. The stresses to which the mold box of a press is subjected, especially when comparatively dry clay is compressed to the form of a brick, are much greater than is generally supposed. Take the case of a "face brick" made on a dry press. Dry pulverized clay is used, and, after being poured into the mold boxes of the press, enough power has to be applied to compress this clay into bricks having smooth surfaces and sharp edges; these bricks must also be hard enough to allow stacking them in a kiln thirty high, without losing their shape. Certain clays require a pressure of from 40,000 to 50,000 pounds per square inch, before these results can be obtained.

An idea of the stresses set up and the forces that have to be applied in brickmaking, may be obtained from the following quotation taken from the catalogue of a well-known manufacturer of brick machinery. "A press that will turn out 2800 dry pressed bricks per hour, weighs 51,000 pounds, requires 25 H. P., and the guides which receive the thrust of the plungers are built to withstand a tensile strain of 6,078,000 pounds." Re-presses which are used to press bricks after they are already formed, also require very high pressures in order to press out all cavities and produce bricks having smooth surfaces and well defined edges. For some clays a unit pressure of 2000 to 3000 pounds is required.

* * *

DON'TS FOR DRILLING MACHINE OPERATORS*

BY JAMES E. COOLEY†

Don't forget when using a head counterbore to try the head of the screw in a hole often, to see if it is cutting the right depth.

Don't take it for granted that the drill you called for at the tool-room has been given you; look at it and see if it is the right size.

Don't brush cast-iron chips off the table onto the floor but catch them in a box; this action raises a dust which gets into the machine bearings.

Don't run a tap in a hole with the tapping fixtures, unless you have first measured the hole to see if it is drilled large enough.

Don't use a knee or angle-plate or parallels without first assuring yourself there are no nicks in them to make the work out of true.

Don't forget to slightly prick several places around on a scribed circle with the center punch; they will show after the circle has become rubbed out.

Don't push down hard when tapping a hole but give the fixture time to feed the tap in; tapping fixtures are broken by forcing and not because they won't work.

Don't use a drift that passes entirely through the broach in the spindle, because the hammer will strike the spindle on the last stroke or when the drift passes through.

Don't, when using several drills, let a drill follow a very small one or *vice versa* if you can avoid it; use the drills in the order of their nearest diameters if possible.

Don't ever fail to look at the opposite end of a drilled hole to see if there is a ridge on one side of the edge; if there is, it shows that the drill has been ground off the center.

Don't forget to watch and see if the drill is sending up solid or powdered chips; if the latter, the feed is not on tight enough, or the feed belt is loose, or the drill is dull.

* See "Don'ts" for Drilling Machine Operators," published in the November, 1913, number of MACHINERY.

† Address: 46 Wyllys St., Hartford, Conn.

GRINDING WHEEL PROTECTION DEVICES*

REPORT ON INVESTIGATION OF DEVICES MADE BY THE NORTON CO.

BY R. G. WILLIAMS†

Recent discussions in the technical press and publications devoted to industrial safety and welfare work, have forcibly brought to the attention of those most interested, the fact that there is no uniformity or standardization of grinding wheel protection devices. This lack of uniformity has been a serious handicap in the development of safer manufacturing conditions. Attention has also been drawn to the fact that there are no recorded data or observations on which standardization and safety rules can be based. For the purpose of obtaining data and observations on the relative protection offered by an approved type of protection hood and approved beveled steel flanges, the Norton Co., through its research laboratories, conducted a series of tests.

The testing equipment consisted of an up-to-date grinding wheel stand driven by a 7½ horsepower gasoline engine (see Fig. 1). A wooden framework of heavy timbers was built over the side on which the flanges were tested, to intercept pieces of the wheels which might possibly break off outside the flanges. In all tests, the wheels were operated at 6000 peripheral feet per minute, the speed being very carefully regulated immediately before each test.

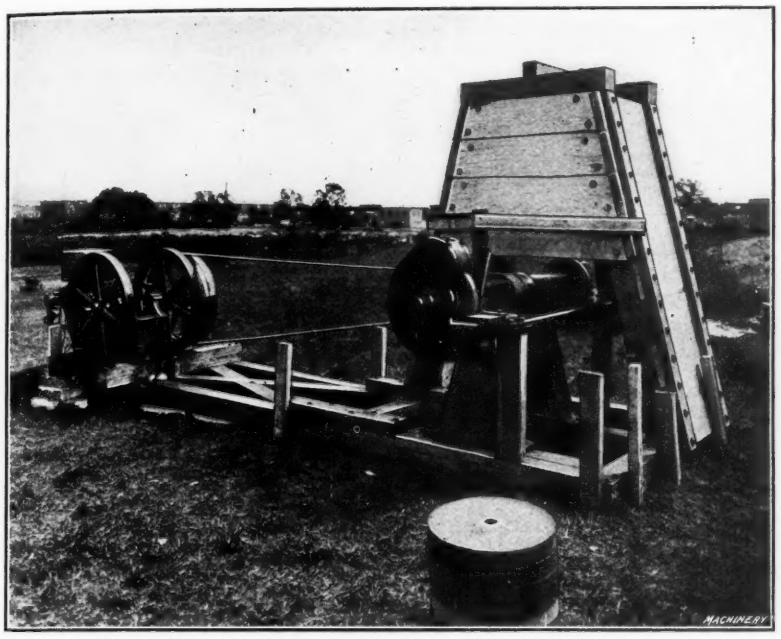


Fig. 1. Testing Equipment consisting of Norton Floor Stand operated at a Speed of 6000 Surface Feet per Minute for All Tests

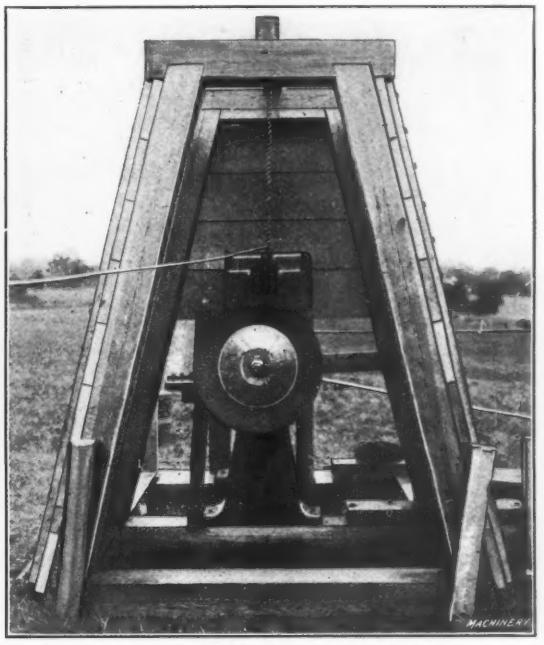


Fig. 2. Wheels broken by swinging 130-pound Weight against the Side

Hood Tests

The wheels used for the hood tests were 16 by 2 by 1¾-inch, alundum, vitrified, of various grains and grades and had parallel sides. The hood was a modern type, and the wheels were mounted between relieved cast-iron flanges 8 inches in diameter. One layer of blotting paper of standard thickness was used between the wheel and each flange. The nut on the spindle was not tightened excessively, but drawn up enough to hold the wheel firmly. The wheels in the hood tests were broken by dropping a steel wedge between the rest and the side of the wheel, in such a manner as to provide a severe blow. The object was to duplicate, as nearly as possible, one of the most frequent causes of accident, *viz.*, that of the work being caught between the rest and the wheel.

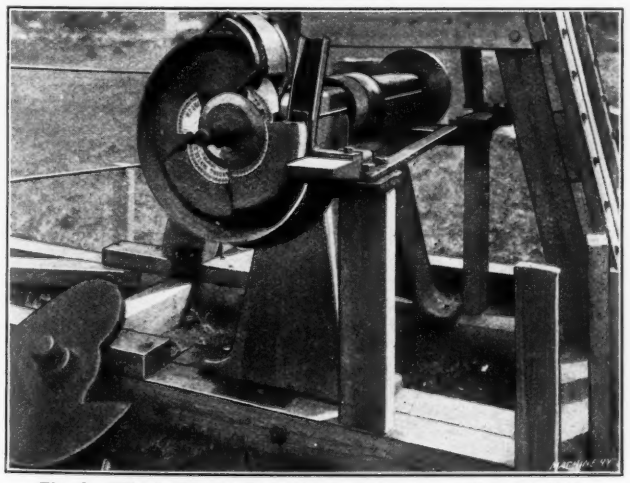


Fig. 3. Wheel; 16- by 2- by 1¾-inch Alundum, 20-K Vitrified; Speed, 6000 Surface Feet. None of the Broken Pieces escaped from the Hood

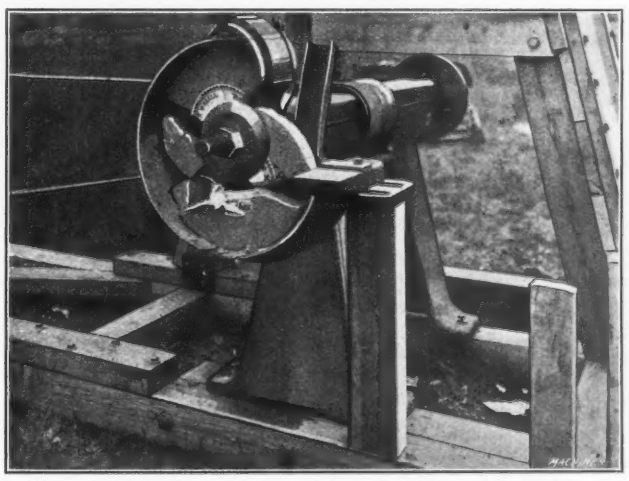


Fig. 4. Wheel; 16- by 2- by 1¾-inch, Alundum, 30-K Silicate; Speed, 6000 Surface Feet. None of the Broken Pieces escaped from the Hood

Flange Tests

The wheels used were all 24 by 2½ by 1¾-inch alundum, vitrified, grain 14, Grade O, tapered both sides ¾ inch to the foot, with a flat at the center of 4 inches diameter. One thickness of standard blotting paper was used between the wheel and each flange. In these tests, five sets of relieved steel flanges, tapered ¾ inch to the foot, were used, the diameters being 12, 14, 16, 18 and 20 inches, respectively.

The wheels in these tests were broken by swinging a 130-

*Paper presented before the American Society of Mechanical Engineers at New Haven, Conn., November 21, 1913.

† Safety Engineer, Norton Co., Worcester, Mass.

pound cast-iron weight against the side of the wheel (see Fig. 2). This method of breakage corresponds to a common cause of accident when heavy castings, which are suspended by tackle above the wheel, are carelessly allowed to strike the side of the wheel with enough force to cause breakage. The manner in which a wheel is broken is not important when protection devices for grinding wheels are being studied, so even though the wheels were broken by different methods in the hood tests and the flange tests, the results obtained are comparative from the point of view of protection to an operator.

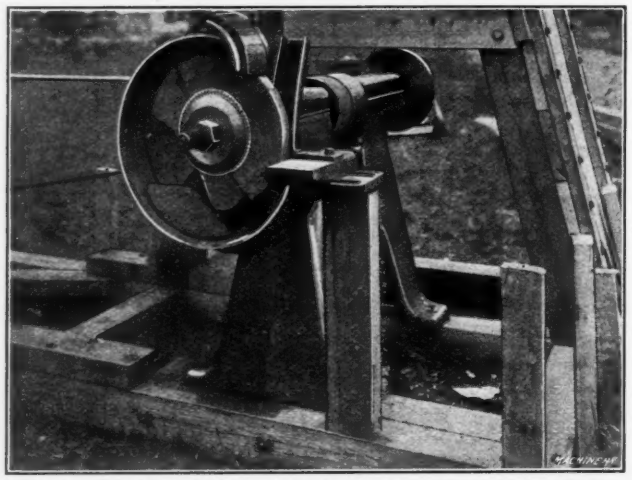


Fig. 5. Wheel; 16- by 2- by 1¾-inch, Alundum, 24-K Vitrified; Speed 6000 Surface Feet. None of the Broken Pieces escaped from the Hood

Observations

In none of the hood tests did a piece of the wheel leave the hood in a way that could have caused damage. The tests show conclusively that a well designed protection hood, made of the right material and properly adjusted, affords ample protection for straight-side wheels even when they are mounted between standard straight relieved flanges having a diameter equal to one-half the diameter of the wheel.

It is possible to break pieces from a wheel by a severe blow when there is only 2 inches of the wheel projecting beyond the flanges. With protection flanges, no matter how little the wheel projects beyond the flanges, an operator has no protection from injury in case a piece of the wheel breaks off outside of the flanges, whereas with a hood, protection is almost absolute.

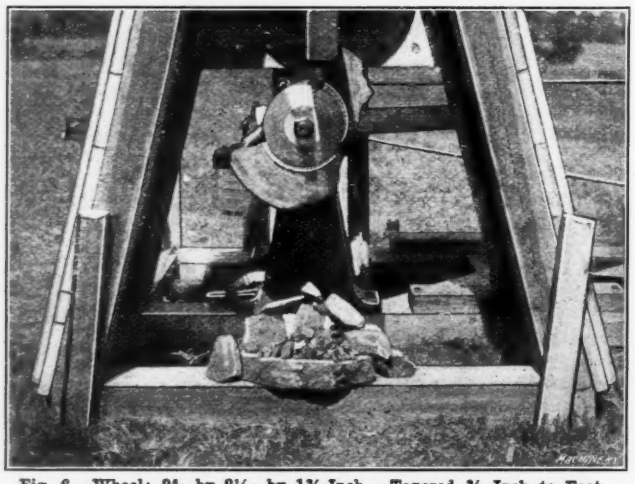


Fig. 6. Wheel; 24- by 2½- by 1¾-Inch, Tapered ¾ Inch to Foot, Alundum, 14-0, Vitrified; Speed, 6000 Surface Feet. Flanges; Steel, 12 Inches Diameter, Relieved, Tapered ¾ Inch to Foot. Wheel broke into Forty-two Pieces and approximately Two-thirds of Wheel escaped from Flanges

Requirements for Hoods and Flanges

It was not the intention to obtain data from which standard specifications for hoods and flanges could be drawn; nevertheless, the tests as a whole brought out a number of points which could be so used. Specifications for hoods for rough grinding should not only require a certain strength, as determined by the design and material used, but they should also require that the top end of hoods have some sliding-tongue device, which can be adjusted as the grinding wheel wears, and thus offer at all times the maximum protection possible. They should also contain a definite statement as to the maximum exposed grinding surface allowable for the common varieties of grinding. For example: Can 60, 70 or 80 degrees of grinding surface be exposed on the type of machine known as the floor stand? Such specifications should also state the minimum size wheel allowable in a hood of given dimensions.

In a majority of instances where protection flanges are now used, ample protection can be obtained by means of hoods without such flanges. However, there are conditions where a hood is not practical and where flanges offer the next best method of protection. The amount of protection offered by flanges is dependent upon the following:

1. The capacity of the flanges to resist the wedging action of a broken piece of the wheel.

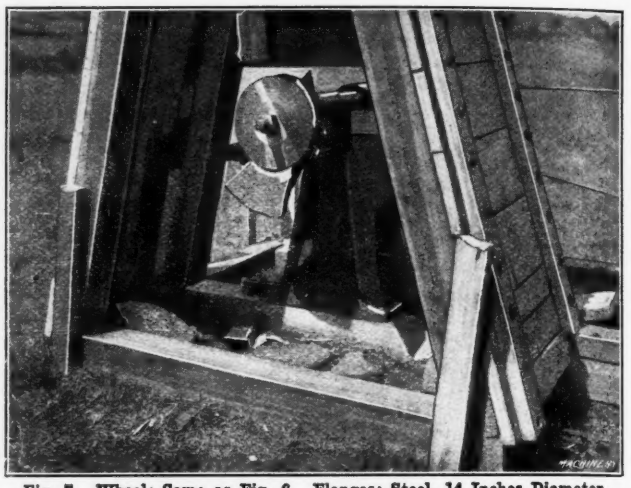


Fig. 7. Wheel; Same as Fig. 6. Flanges; Steel, 14 Inches Diameter, Relieved, Tapered ¾ Inch to Foot. Wheel did not break into as many Pieces as One in 12-inch Flanges. Approximately Three-fourths of Wheel escaped from Flanges

2. The size of flanges.
3. Bevel of the wheel.
4. Peripheral velocity of the wheel.
5. Mass of the wheel.
6. Degree of safety.

Degree of safety, as here used, expresses the relationship between the thickness of the wheel at the hub and the thickness of the wheel at the point where the outer edge of the flanges bears on the wheel. In other words, it is an expression which indicates how much the flanges must spread in order to let out a broken sector of the wheel. If the force acting upon the sector of a broken wheel is great enough to spread the protection flanges a distance equal to *B* minus *A* inches (see Fig. 11), then there is not adequate protection. Sufficient protection can be obtained by (*a*) increasing the thickness of the flanges, (*b*) using flanges of a material with a greater modulus of elasticity, (*c*) increasing the diameter of the flanges, (*d*) increasing the taper per foot of the wheel.

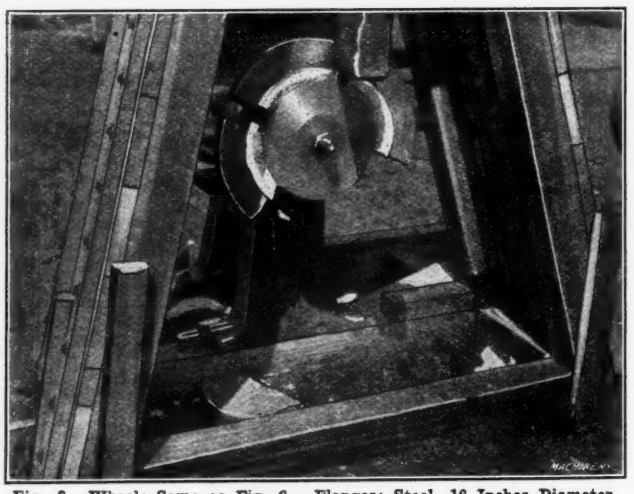


Fig. 8. Wheel; Same as Fig. 6. Flanges; Steel, 16 Inches Diameter, Relieved, Tapered ¾ Inch to Foot. Blow of Weight was not on Piece of Wheel which left Flanges and dropped to Ground. The Part of Wheel struck by Weight was held in Flanges

Some figures obtained from the 16-inch diameter flange test, give a basis on which standard specifications may be formulated. The combination of factors present in this case resulted in what could be termed a critical condition. The wheel broke into four almost equal pieces, the weights of which were about 23½ pounds. The peripheral velocity of the wheel was 6000 feet per minute. The wheel was tapered ¾ inch to the foot, the taper ending 2 inches from the center of the wheel. In order for a sector to fly out of the 16-inch flanges, they had to spread a total of ¾ inch. After the breakage, it was found that the sectors had moved out a little over 5½ inches and the flanges had spread a little over 11/16 inch, or nearly the required distance to let out the sectors.

The shape of the flanges used was such that it has been found impractical to consider them as cantilevers of the same cross-sectional area, and, therefore, the acting forces in the above case, and the exact factor of safety, cannot be calculated readily. For this reason we cannot deduce definite formula relations between the several factors involved. We can, however, find a proportional relation which expresses the relative degree of safety with different size wheels and flanges.

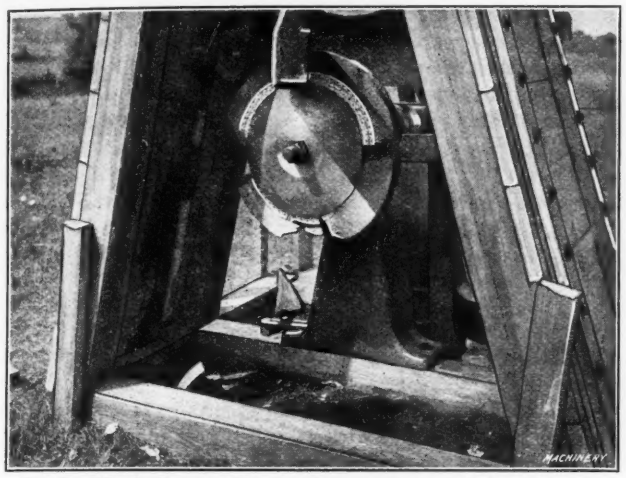


Fig. 9. Wheel; Same as Fig. 6. Flanges; Steel, 18 Inches Diameter, Relieved, Tapered ¾ Inch to Foot. The Piece of Wheel on the Ground was not knocked off by Blow of Weight, but thrown from Flanges by Centrifugal Force and hurled through Opening at Top of Framework into Air about 50 Feet

Flanges 20 inches in diameter must open one inch to let out a sector. This distance is 33 1/3 per cent more than in the case previously cited, so that 20-inch flanges of the same stiffness as the 16-inch flanges would just about hold the quarter sector of a wheel of 33 1/3 per cent greater mass.

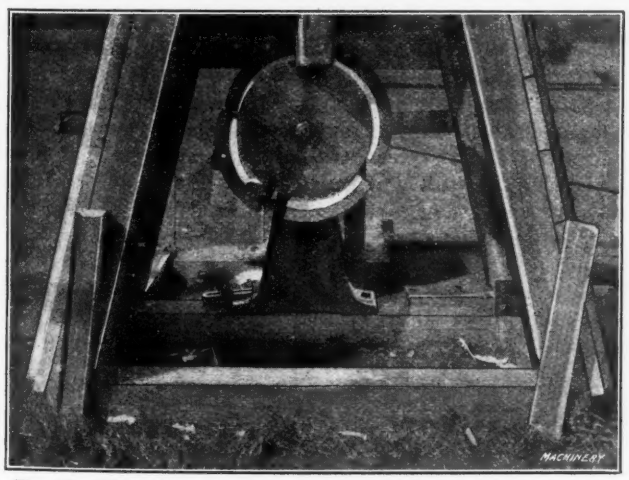


Fig. 10. Wheel; Same as Fig. 6. Flanges; Steel, 20 Inches Diameter, Relieved, Tapered ¾ Inch to Foot. All Segments were retained by Flanges which are only 4 Inches less than Wheel Diameter

The size of a 24-inch wheel of 33 1/3 per cent more mass than a 24 by 2½-inch wheel, would be about 24 by 3⅜ inches. Since 20-inch flanges are as large as is practical to use on wheels 24 inches in diameter, it is quite obvious that 24-inch wheels of a thickness greater than 3½ inches are not safely guarded by means of ¾-inch taper protection flanges, unless the flanges are made more rigid than most existing flanges. Standard specifications should require a factor of safety of at least 2. This requires a greater taper than ¾ inch to the foot, or the use of very heavy steel flanges.

Conclusions from Tests

The tests conducted and the mathematical deductions given above, show that protection hoods provide greater safety than do safety flanges. The protection offered by any given taper decreases with decreased diameter of the wheel. To provide equal safety on all sizes of wheels would require, therefore, a graduated difference in taper. A hood with an adjustable tongue furnishes equal protection for a wide range in the diameter of wheels.

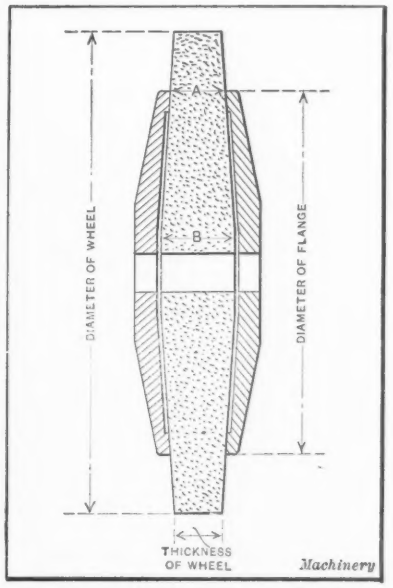


Fig. 11. Sectional View of Tapering Grinding Wheel and Protection Flange

Second to safety, the cost of operating a given grinding machine is of vital interest. In this respect, adjustable hoods have the better of the argument for, as the wheel wears, protection flanges must be changed frequently. Such change involves the removal and remounting of the two flanges and wheel, whereas, in the case of a hood, the change would merely involve set-screw adjustment.

To provide adequate protection for wheels 3 inches and thicker, the thickness (hence the weight) of flanges would have to be increased beyond that of any flange now on the market. This would mean added momentum to the revolving spindle, which, in turn, would require greater rigidity and strength than is to be found in the majority of present-day grinding machines.

Since the face of a tapered wheel becomes wider as the diameter decreases, serious inconvenience is caused in all grinding where the wheel must work in a slot. Tapered wheels do not permit the grinding of right-angle shoulders as do straight wheels. Laws in almost every country require the removal of dust from grinding. This requires the use of a hood, and if a hood must be used, it might just as well be strong enough to offer protection in case of accident. A proper hood offers complete protection. Protection flanges cannot offer this complete protection, but in instances where a hood would interfere with the proper use of the wheel, flanges offer the next best method.

* * *

RUSSIAN EXPORT TRADE

Are American machine builders who are looking for an export trade fully aware of the fact that Russia, at the present time, offers one of the greatest opportunities for trade expansion? Germany is working this field very diligently and has a firm grasp on the Russian machine trade. Russia, in fact, is one of Germany's most important customers in the machine field. Sweden also exports to Russia a large percentage of the machinery built in that country, and many of the machine industries in Sweden depend largely upon the Russian market. Whether or not the abrogation of the treaty between the United States and Russia would have any influence on the conditions of trade between the two countries is difficult to say; but there seems to be no reason why Russia should not be just as willing to do business with American exporters as with Germans, unless the absence of the treaty makes a material difference in our trade with Russia. Germany and Sweden have no advantage except the proximity of territory. This, of course, counts for something, but in these days of rapid transportation, the odds against American manufacturers on this account should not be insurmountable.

GEARS FOR MACHINE TOOL DRIVES*

MATERIALS RECOMMENDED FOR THE VARIOUS GEAR COMBINATIONS MET WITH IN MACHINE TOOL DESIGN

BY JOHN PARKER†

The basis of this paper is the consideration of the six following questions relating to the use of gears for driving machine tools:

1. Under what conditions is it advisable to use cast-iron or steel gears for machine-tool drives?
2. Are the objections to cast iron on the ground of wear or breakage?
3. What tooth pressure is safe for cast-iron gears?
4. What grades of steel give best results and how should they be treated?
5. How hard is it advisable to make steel gears before machining them?
6. Are they to be hardened after machining, and if so, to what scleroscope test?

Conditions Governing use of Cast-iron and Steel Gears

There are a number of well established gear conditions that are common to the majority of machine tools, which, if noted, may prove somewhat of a guide in selecting the proper material for the gears, considered from the standpoints of economy, efficiency and durability. The conditions may be classified, as in the accompanying table.

GEAR CONDITIONS COMMON IN MACHINE TOOLS

			Material
A	Gears always in mesh, the wear on the teeth being constant	(*a*)	Slow speeds, light duty — Cast Iron
		(*b*)	Slow speeds, heavy duty — Machine steel
		(*c*)	Fast speeds, light duty — Machine steel
		(*d*)	Fast speeds, heavy duty — Machine steel, casehardened
B	Gears in sets that are removable and interchangeable with each other, distributing the wear over a number of gears	These are change gears used in thread cutting on lathes, spiral cutting on milling machines, indexing on automatic gear cutters and feed and speed change gears; speeds and pressures are generally moderate	Cast iron, excepting the smallest, which may require to be of steel
C	Gears in sets that are non-removable and partially interchangeable, distributing the wear over a number of gears. Changes made while gears are in motion*	Used as quick-change feed gears—changes made by levers; speeds and pressures moderate	Machine steel, casehardened
D	Gears in sets that are non-removable and partially interchangeable, distributing the wear over a number of gears. Changes made when gears are at rest†	Used as quick-changespeed gears — changes made by levers; high speeds and heavy pressure	Machine steel, casehardened
E	Gears that are employed only part of the time the machine is working, and are engaged and disengaged when the machine is stopped	This condition applies to back-gears for the spindle drive. Gears are made large diameter, coarse pitch and wide face; speeds moderate and heavy pressure	Hard, close-grained cast iron

* If the changes were made when the machine was at rest, the gears would not require hardening. But custom demands that changes be made while the machine is running.

† Although the changes are supposed to be made when gears are at rest, careless workmen will violate this rule, with the possibility of breaking the engaging gears. Some makers use an alloy steel in their spindle train to prevent breakage, but a better way is to provide means whereby it is necessary to stop the machine before throwing in the gears. This applies to the tumbler type of change gearing.

The objections to cast iron cover both wear and breakage. If the speed is excessive, say about 500 feet per minute, they are likely to wear quite rapidly; and on slow speeds and heavy pressure breakage will occur, unless they can be made of adequate size, as in the case *E*, where the back-gears are so located in the machine that it is possible to employ large diameters, coarse pitches and wide faces.

Safe Tooth Pressure for Cast-iron Gears

The question of tooth pressures in cast-iron gears is somewhat problematical. The Brown & Sharpe Mfg. Co. has in successful operation a gear in the spindle drive of its largest milling machine, made from a hard, close-grained cast iron having a tensile strength of 23,000 pounds per square inch, which, when running at the slowest speed, sustains a pressure on the teeth of 8250 pounds. It is calculated that two teeth are always in contact, which gives 4125 pounds pressure per tooth. The area in cross-section of each tooth is 1¼ square inch, equaling 3300 pounds per square inch. When the gear runs at the fastest speed the pressure is about 1000 pounds per square inch. It is not known whether the pressure could be increased to any considerable extent, but it has been overloaded to at least 30 per cent without injuring it; this was when testing out the machine and the overload was of short duration. It might be said that this gear is not subjected to any sudden shock; if it were, the allowable tooth pressure would be considerably less.

Grades of Steel that give Best Results and Heat-treatment

For gears that are of small proportions and yet are subjected to heavy duty, it has been found that in cases where the more common steels have failed, excellent results have been obtained from using a 5 per cent nickel steel. This steel casehardens with a very hard surface and still has a strong and tough core, making it an ideal steel to use where the pressure is heavy or the gear is subjected to shock. Experience shows that drop-forgings are more uniform in texture than bar stock. This grade of steel is given an oil treatment and is also annealed before machining. The oil treatment is as follows: heat to 1550 degrees F. and quench in oil. To anneal, reheat to 1350 degrees F. and cool very slowly. The steel is then ready to machine.

After machining, it is carbonized as follows: Pack in any good carbonizing material and cover very carefully to exclude air; place in furnace and heat to 1700 degrees F., and hold long enough to get the desired depth of casing. Care should be taken to have the steel heated entirely through. Ordinarily from three to four hours is sufficient. Then remove the steel from the furnace and cool in the boxes; then remove from the boxes and place in a furnace or bath; reheat to 1550 degrees F. and quench in oil. Again reheat to about 1380 degrees F. and quench in oil or water, according to the size and shape of gear. If the gear is of generous dimensions and free from sharp corners, water is preferable. Small slender gears are quenched in oil, on account of the liability of cracking if water is used. For ordinary gears the scleroscope test should show 80 to 85 points of hardness. If the gears are used as clash gears they should be drawn to 475 degrees F., or about 70 to 75 points of hardness, by scleroscope test, to avoid chipping.

Hardness Advisable for Steel Gears before Machining

The kinds of steels used for gears are of such a nature that they do not call for heat-treating before machining, but where extra toughness in shafts is required to withstand torsion and bending strains, 3½ per cent nickel steel is satisfactory and is heat-treated as follows, after being rough-machined: Place in an open furnace or bath, heat to 1500 degrees F. and quench in oil. It is advisable to experiment with a small quantity in each batch, before subjecting a whole lot to the drawing out heat, which should begin at about 700 degrees F. If the scleroscope registers between 50 and 58, the correct hardness has been obtained; if higher than 58, the parts should be reheated to a higher temperature than before; if lower than 50, the parts must be rehardened. After this treatment,

* Paper presented before the American Society of Mechanical Engineers, December, 1913.

† Address: Brown & Sharpe Mfg. Co., Providence, R. I.

the pieces are finish-machined. No further hardening is necessary. When machining, slow speeds and feeds must be used.

Hardening after Machining, and the Scleroscope Test

Practically all alloy and all low-carbon steels are hardened after machining and finished by grinding after hardening. About 0.010 inch on the diameter is left for this operation. All gears should run true, and to obtain this result not only are the holes ground true with the pitch circle, but the hubs are ground on their faces so they will set square with their shafts when tightened up by nuts. The scleroscope test for 30 to 35 point carbon machine steel is anywhere from 80 to 90, and for 5 per cent nickel steel for ordinary gears, 80 to 85, and for clash gears, 70 to 75. All steels are tested by the file in addition to the scleroscope. The file test by an expert is very reliable and some feel that possibly more confidence can be placed on his judgment than on any testing instrument.

The above notes apply to spur and bevel gears. For worm and worm-wheel drives, the worm should be made of machine steel, casehardened, and the wheel of a hard bronze. Both should run in a bath of oil, especially if under high speed and heavy duty. Spiral gears should be used only where the duty is light. The material should be the same as for a worm and worm-wheel, and they should also run in oil to avoid cutting.

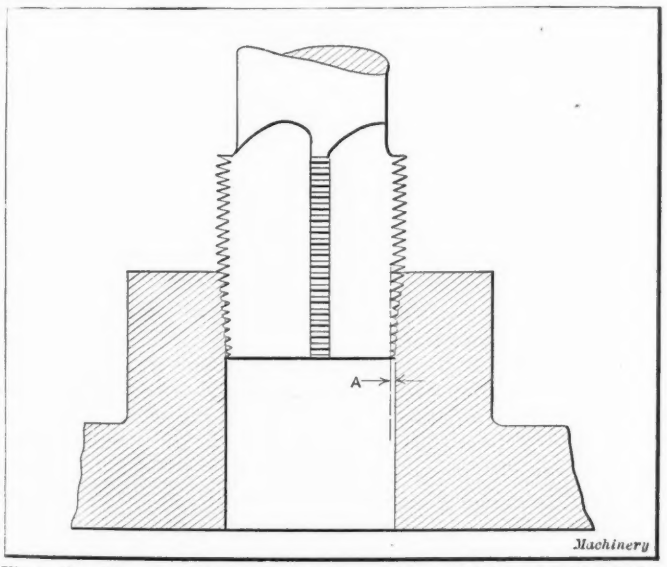
For index mechanisms where accuracy is essential, if the worm is hardened, the thread must be ground afterwards. This is done in all the spiral heads of Brown & Sharpe's make. Generally, the worm, which is made of tool steel, is left soft. Worm-wheels used for indexing purposes only are usually made of cast iron, and invariably if of large diameter. High-multiple threaded worms for indexing mechanisms should not be used; a double thread can be tolerated, but not more, if accurate indexings are required.

* * *

TAP DRILL SIZES

BY ALBERT A. DOWD*

The correct size of drill which should be used for a hole that is to be tapped subsequently, seems to be somewhat variable, and the result of this uncertainty is that the amount of thread remaining after the hole has been finished is sometimes insufficient to perform its function. Nearly all factories have tabulated lists for reference in the "tool crib," giving correct tap drill sizes for standard holes. These are of great value in the general run of manufacturing where the tapping is to be done on a tapping machine or by means of a tapping attachment. There are cases, however, where the drill sizes given are so proportioned that the tap clearance at the root of the thread is insufficient for machine tapping, although it may be all right for hand tapping. When this is the case, taps are frequently broken. In other instances the tap drill size specified is too large, resulting in the saving of taps but giving an inferior product on account of lack of thread surface.



Illustrating Clearance between Thread Root of Tap and Wall of Drilled Hole

The illustration shows a drilled hole with the tap in position, indicating at A the amount of clearance between the thread root of the tap and the wall of the drilled hole. This clearance should vary in proportion to the pitch of the thread, for if not so proportioned the relative strength of the different pitches will not be the same. In determining this clearance, two points must be considered, *viz.*, the diameter of the hole and the strength of the tap. For example, a ½-inch tap, 40 pitch, is obviously much stronger than a ⅛-inch tap of the same pitch. We must also bear in mind that for machine tapping the clearance should be greater than for hand tapping, in order to avoid the breaking of taps as much as possible. The formulas given herewith are proportioned for both machine and hand tapping and will be found of considerable assistance in determining drill sizes.

Formulas for Tap Drill Sizes

T = tap size specified;
MTD = tap drill size for machine tapping;
HTD = tap drill size for hand tapping.

Then

$$MTD = T - 0.8\left(\frac{1.299}{\text{pitch}}\right)$$

$$HTD = T - 0.9\left(\frac{1.299}{\text{pitch}}\right)$$

For example, let it be required to ascertain the correct tap drill size for a ⅜ 16-pitch thread, for machine tapping. Applying the formula we have:

$$0.375 - \frac{0.8 \times 1.299}{16} = 0.31005,$$ and the nearest drill size is 5/16, or 0.3125 inch.

CONSTANTS FOR TAP DRILL SIZES

Threads per Inch	U. S. Standard Constants	Machine Tapping Drill Constant	Hand Tapping Drill Constant	Threads per Inch	U. S. Standard Constants	Machine Tapping Drill Constant	Hand Tapping Drill Constant
64	0.0203	0.0162	0.0182	16	0.0811	0.0649	0.0730
60	0.0216	0.0173	0.0194	14	0.0927	0.0742	0.0835
56	0.0232	0.0185	0.0208	13	0.0999	0.0799	0.0899
50	0.0259	0.0207	0.0233	12	0.1082	0.0866	0.0974
48	0.0270	0.0216	0.0243	11½	0.1129	0.0903	0.1016
44	0.0295	0.0236	0.0265	11	0.1180	0.0944	0.1062
40	0.0324	0.0259	0.0292	10	0.1299	0.1039	0.1169
36	0.0360	0.0288	0.0324	9	0.1443	0.1154	0.1299
32	0.0405	0.0324	0.0365	8	0.1623	0.1299	0.1461
30	0.0433	0.0346	0.0389	7	0.1855	0.1484	0.1670
28	0.0463	0.0371	0.0417	6	0.2165	0.1732	0.1948
27	0.0481	0.0384	0.0433	5½	0.2361	0.1889	0.2125
26	0.0499	0.0399	0.0449	5	0.2598	0.2078	0.2338
24	0.0541	0.0433	0.0487	4½	0.2886	0.2309	0.2598
22	0.0590	0.0472	0.0531	4	0.3247	0.2598	0.2922
20	0.0649	0.0519	0.0584	3½	0.3711	0.2969	0.3340
18	0.0721	0.0577	0.0649	3	0.4330	0.3464	0.3897

Machinery

The formulas given above will take care of any condition or pitch of thread, but for small diameters, say from ⅛ to ¼ inch, it is advisable to select a drill from 0.002 to 0.004 inch larger than the figured dimensions.

Formulas for Tap Drill Sizes using Constant Table

The table gives constants which may be used for the more frequently used pitches and will be found convenient. These are subtracted from the outside diameter of the tap or screw to find the diameter of the tap drill for machine tapping and hand tapping.

T = nominal size of tap specified;
C = double depth of thread;
MD = constant for machine tapping;
HD = constant for hand tapping;
MTD = tap drill size for machine tapping;
HTD = tap drill size for hand tapping.

Theoretical size of tap drill required = $T - C$

$$MTD = T - MD$$

$$HTD = T - HD$$

* Address: 84 Washington Terrace, Bridgeport, Conn.

TESTS FOR STRENGTH OF GEAR TEETH

The report of tests for strength of gear teeth given in the accompanying table was supplied by Mr. Andrew C. Gleason to supplement his paper on "The Use of Heat-treated Gears in Machine Tools" (see page 290, engineering edition, of the December number).

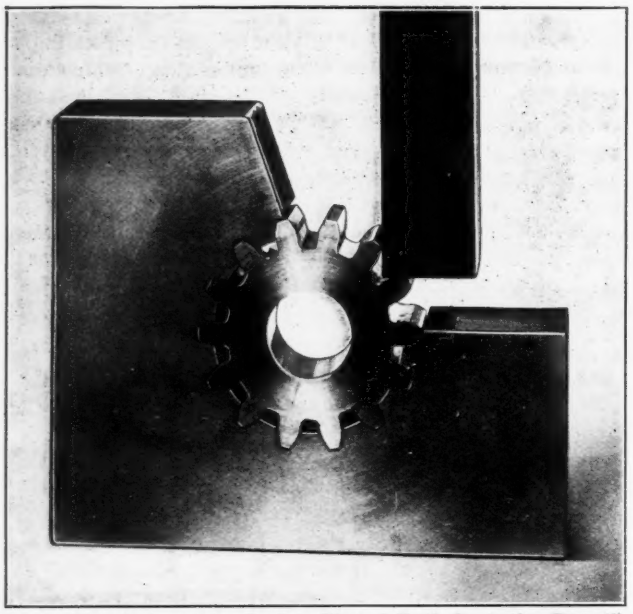


Fig. 1. Method of applying Load to Edge of Tooth for testing Strength

ULTIMATE STRENGTH AND ELASTIC LIMIT OF GEAR TEETH FOR DIFFERENT STEELS AND HEAT-TREATMENTS

Heat-Treatment	Elastic Limit	Breaking Strain
0.20 Carbon, Open Hearth Casehardening Steel		
No. 1. Soft	3500	
No. 2. Casehardened with one tempering heat of 1450° F., 90 scleroscope hardness..	8400	9000
Same drawn to 400° F., 85 scleroscope hardness	8000	9450
No. 3. Casehardened with two tempering heats of 1600° F., and 1450° F., 85 scleroscope hardness	8200	9675
Same drawn to 400° F., 80 scleroscope hardness	8000	9800
1½ per cent Nickel, 0.18 Carbon, Natural Alloy Steel		
No. 1. Soft	4000	
No. 2. Casehardened with one tempering heat, 92 hardness	9000	10,150
Same drawn to 400° F., 87 hardness..	8600	10,450
No. 3. Casehardened with two tempering heats	8750	10,600
Same drawn to 400° F., 82 hardness..	8400	10,750
3½ per cent Nickel, 0.13 Carbon, Open Hearth Nickel Alloy		
No. 1. Soft	4000	
No. 2. Casehardened with one tempering heat of 1350° F., 90-95 hardness	9700	11,400
No. 3. Casehardened with two tempering heats of 1550° F., and 1350° F., 90-95 hardness	9500	11,650
Same drawn to 400° F., 85 hardness..	9250	11,950
5 per cent Nickel, 0.15 Carbon, Open Hearth Alloy Steel		
No. 1. Soft	4500	
No. 2. Casehardened with one tempering heat of 1350° F., 90 hardness	13,000	13,880
Same drawn to 400° F., 85 hardness..	12,700	14,800
No. 3. Casehardened with two tempering heats of 1550° F., and 1350° F., 90 hardness	13,000	14,100
Same drawn to 400° F., 85 hardness..	12,800	14,850
(A) Chrome-nickel Tempering Steel		
No. 1. Quenching heat 1425° F., drawing temperature 475° F., 65-70 hardness		22,450*
No. 2. Soft	5000	
(B) Chrome-nickel Tempering Steel		
No. 1. Quenching heat, 1480° F., drawing temperature, 525° F., 75-78 hardness		17,640*
No. 2. Quenching heat, 1480° F., drawing temperature, 850° F., 60-65 hardness		19,440*
No. 3. Soft	5200	

* No set before breaking.

These tests represent average results obtained from a considerable number of test pieces subjected to the different heat-treatments specified in the table. The test pieces were spur pinions having fourteen teeth of six pitch, 2 1/3 inches pitch diameter, 1-inch face width and 1-inch bore. All teeth were of standard depth and shape. During the tests the pinions were held in a special chuck as shown in the accompanying illustrations, the load being applied to the edge of the teeth as indicated in Fig. 1. The initial displacement or elastic limit was determined by following up the load with a vernier tooth caliper which showed when permanent set had occurred (see Fig. 2). All carbonizing was 1/32 inch deep, and the furnace temperature varied from 1450 to 1500 degrees F., for eight hours, and was held at 1600 degrees for from three to five hours—a total of eleven to thirteen hours.

It will be noted that the increased strength, as a result of the double heat-treatment after carbonizing, is comparatively slight, particularly in the nickel-alloy steels. This is undoubtedly due to the long and low carbonizing heats and the low hardening heats. The various hardened test pieces of the "straight-carbon" steel showed a variation in strength of 10 per cent above and below the records given. This stock was selected especially for casehardening and, according to our experience, the ordinary run of machine steel of the same carbon content would vary, in some cases, twice as much as this. The same may be said of the so-called "natural nickel-

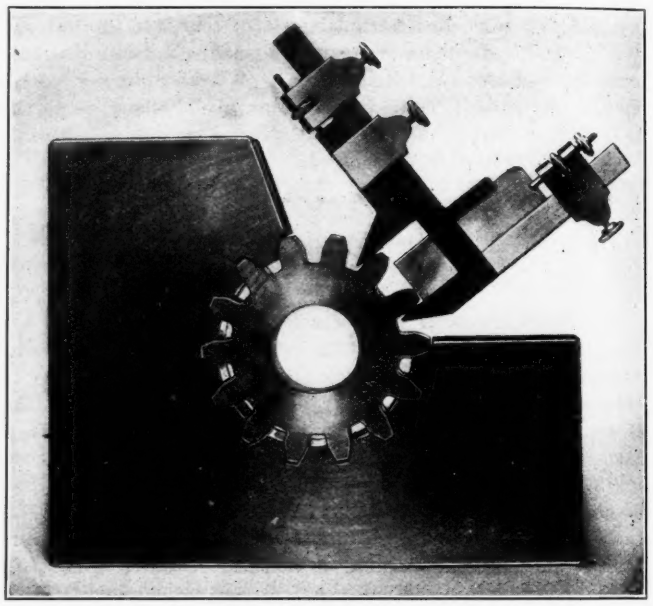


Fig. 2. Gear Tooth Caliper used to determine when Permanent Set occurred

alloy steels," as we find that they vary as much as the straight-carbon steels. The higher grade of alloy steels did not vary more than 10 per cent either way, and the average was closer.

* * *

LOOK OUT FOR THE "BORROWER"

Some time ago we were favored with a visit from a man claiming to be C. E. Watson who was connected with the Case Crane & Engineering Co., Columbus, Ohio to whom we recently made shipment of a machine. He knew all about some minor defects of the machine and we had no reason to question his integrity, and as he was short of funds, we cashed a check for $35 on one of the Columbus banks. The check was returned protested "Not Known." Since that time we have received letters from the Laughlin-Barney Machinery Co., of Pittsburg and the Detrick & Harvey Machine Co., of Baltimore, advising us that the same man had obtained money from them, in the same manner, only that he claimed to be connected with the Babcock & Wilcox Co., of Barberton, Ohio. This "worthy" gentleman was connected with the Case Crane & Engineering Co., as we found out from them and was formerly connected with the Crucible Steel Company of America and we believe he was at one time an engineer in the Navy. We think it is high time that notice was given, so that other people will not be duped the same as we were.

Philadelphia, Pa. NEWTON MACHINE TOOL WORKS

CAST IRON FOR MACHINE TOOL PARTS*

A STUDY OF FOUNDRY MIXTURES USED AND RECOMMENDED BY MACHINE TOOL BUILDERS

BY HENRY M. WOOD†

When considering what sort of iron to use for various purposes, the machine tool manufacturer is interested chiefly in the results attained by the foundryman, *i. e.*, the strength, soundness, hardness, etc., of the casting, rather than the foundry methods used in accomplishing such results. Nevertheless as an investigation of the character of the casting is made through chemical analysis, it is well first to consider the effect of each of the elements usually present in cast iron.

Influence of Chemical Elements

The five elements present in ordinary cast iron are carbon (both free as graphite and combined), silicon, sulphur, manganese, and phosphorus.

Carbon. Carbon exerts a more important and direct influence on the quality of the metal than does any other element. The percentage of carbon in the casting and the form in which it exists are dependent upon the melting conditions, the thermal treatment, and the amounts of other elements present. Therefore it is necessary to take account of the effects of the carbon itself and the way its influence is modified by the presence of varying quantities of other elements. To obtain a proper relation between combined and free carbon is the most important point. The percentage of total carbon usually ranges from 3.5 to 4 per cent.

Graphitic Carbon. Graphite is merely mixed with the iron instead of being in chemical combination. Since it is only mixed with the metal it cannot exert any direct influence upon the properties of the molecules of the iron. So far as the graphite itself is concerned, the toughness, hardness and melting point of the grains of the iron will not be altered. The tensile strength will, however, be greatly affected, since the interposition of the flakes of graphite will act as partings between the grains of the metal and reduce the cohesion. Iron high in graphite is soft and can be machined readily, but is of low tensile strength.

Combined Carbon. The carbon which is in chemical combination affects directly and greatly the properties of ordinary cast iron. It is the principal factor in determining the hardness, tenacity, soundness, and freedom from internal stresses of the castings. In general, the percentage of combined carbon ranges from 0.05 in the softest cast iron to about 0.60 in iron of the highest elasticity. With suitable iron mixtures the amount of silicon and sulphur present, regulates the separation of carbon as graphite so that the amount of silicon present is an index of the relation between the free and combined carbon. Many analyses submitted do not state the percentage of carbon, perhaps because the foundrymen do not appreciate the importance of it, or perhaps because they consider the quantities of silicon, manganese and sulphur, which influence the quantity of combined carbon, make it unnecessary to determine the latter.

Silicon. Silicon tends to cause separation of the carbon as graphite. As the hardening effect of the silicon necessary to do this, is less than that of the combined carbon converted into free carbon, the net result of adding silicon is softer iron. Under conditions which are easily regulated by selection of materials and in other convenient ways, the general influence of silicon can be utilized to render the cast iron suitable for various purposes, but it must be used with due regard to the other constituents of the metal.

Sulphur. The influence of sulphur is opposite to silicon, in that it makes the iron harder and more brittle. It makes the iron more sluggish when pouring and is liable to cause unsound castings. Sulphur increases shrinkage, resulting in internal stresses of unknown value and sometimes producing distorted castings. This element should be kept low, especially in small castings.

Manganese. One effect of manganese is to combine with sulphur and go off in the slag. Another is to retard the separation of graphite by combining with carbon, and in this its influence is opposite to that of silicon, rendering the iron harder, stronger and perhaps closer.

Phosphorus. Phosphorus lowers the melting point and increases the fluidity of the molten iron. On the other hand, phosphorus makes the casting harder, more crystalline and brittle, and reduces the tensile strength.

Special Mixtures

Semi-Steel. This mixture is obtained by charging mild steel scrap into the cupola. It is common practice to use about 20 per cent steel, but any amount up to 70 per cent may be used. The 20 per cent mixture usually gives the desired results for machine tool work. Semi-steel is lower in total carbon than cast iron, seldom having more than 3 per cent. The fine grain of semi-steel is due to low percentage and fineness of graphite. It is used for parts requiring good appearance, tensile strength, and ability to resist shock. It is often used for large gear blank castings for various machine tools, for milling-machine tables, knees, and saddles, for lathe reverse plates, compound rests, etc. The tensile strength is relatively high and the grain of the casting is close.

Alloys. Elements sometimes introduced into cast iron for special purposes are vanadium, titanium, nickel and chromium. Vanadium increases the resistance of the casting to wear. Titanium combines with nitrogen and goes off in the slag, thus acting as a scavenger and making closer and cleaner iron. While nickel and chromium are now used to a limited extent in heavy chilled castings such as car wheels and rolling-mill rolls, the writer has been unable to find instances of the use of these metals in cast iron for machine tool parts.

Mixtures used by Representative Machine Tool Makers

In the belief that valuable information could be secured by a comparison of the present practices of representative machine tool manufacturers, the writer asked a number of machine tool makers in different lines and in different sections of the country if they would be willing to submit an outline of their practice. The following is quoted from their replies:

Two Plain	
Manganese	0.60 to 0.90
Phosphorus	0.50 to 0.80
Sulphur	0.05 and under
No. 3	
Silicon	1.00 to 1.50
Manganese	0.50 and over
Phosphorus	0.50 to 0.80
Sulphur	0.07 and under

In addition to the above we use materials as follows: No. 1 machinery scrap, mild steel scrap, manganese steel scrap. The last carries 12 per cent of manganese with quantities of the other elements so small that they are negligible in gray iron foundry work. Our mixtures are figured out on the actual analysis of each car, insuring in the castings uniformity of analysis and consequently of physical characteristics, such as strength, density, and machining qualities. In general practice we use three different mixtures suited to our needs.

In our first mixture we include our lighter castings such as pulleys, small gears, washers, handwheels, brackets, and the like. In this mixture we try to have the following analysis:

Silicon	1.90
Manganese	0.60
Phosphorus	0.70
Sulphur	0.08

This is usually secured by the use of a mixture of 50 per cent of two or three lots of "two plain" iron and 50 per cent of scrap. The proportions of the different pig irons are adjusted to produce the proper analysis in the mixture, and the scrap is partly our own foundry return, the balance being No. 1 machinery scrap.

Our second mixture covers all our heavy work, such as planer beds, posts, tables, faceplates, frames, etc. These castings require strength and sufficient density to permit the

* Paper presented before the American Society of Mechanical Engineers, December, 1913.

† Lodge & Shipley Machine Tool Co., Cincinnati, Ohio.

machined surface to take a high polish. The analysis is:

Silicon	1.40
Manganese	0.60
Phosphorus	0.60
Sulphur	0.09

This mixture consists of 45 per cent of two or more "No. 3 irons" and 55 per cent total scrap, shop and No. 1 machinery together. Should this mixture fail to yield sufficient manganese, the addition of 1 to 2 per cent of manganese steel scrap is made to correct it.

The third mixture is semi-steel, used principally for large blank gears and castings requiring special strength. Its analysis is:

Silicon	1.20
Manganese	0.90
Phosphorus	0.45
Sulphur	0.09

Its average makeup is:

Machinery scrap	30 per cent
Mild steel scrap	20 per cent
Manganese steel scrap	5 per cent
No. 3 pig iron	45 per cent

All materials are weighed before charging into the cupola and all due precautions are taken to insure proper melting conditions and perfect mixtures of the various materials.

A Manufacturer of Precision Machinery: In our work we run various grades of iron to meet the conditions existing in the machines or in the parts of machines under consideration.

In a general way our mixtures, in per cent, run as follows:

Silicon	Manganese	Phosphorus
3.00	0.60	0.08
2.40	0.65	0.70
2.00	0.65	0.60

The first is for the average run of castings of smaller size; the second for the larger castings. Where we need a special close-grain iron we use the third mixture.

A Manufacturer of Milling Machines: We have never carried on any extensive experiments to learn the best mixtures of cast iron for our purposes. We use in the tables, knees, saddles and vises about 20 per cent of steel with a view to obtaining a close-grain casting, and increasing somewhat its strength. We use practically no cast iron for gears or small parts, these being made of steel, drop-forged in the case of larger parts, and also in the case of smaller parts when not adapted for manufacture from the bar. The subject of gray-iron castings is, we believe, one of the most annoying to be found in connection with the manufacture of machine tools. Customers are not satisfied to accept machines with defective castings even though the deficiency is of such a nature as to, in no wise, impair the life or efficiency of the machine. The ideal casting is, of course, one that is so close as not to show any grain when finished and at the same time, just as hard as it can be, and be worked into shape. The question of strength is probably not so important, as there is opportunity to use sufficient bulk to obtain strength. At any rate this is true of the parts that we make of cast iron, for, as stated above, all our gears, etc., are made from casehardened steel.

A Manufacturer of Heavy Lathes: With the heavier castings we are using a semi-steel mixture with about 20 per cent of steel. The analysis of this iron shows 1.60 to 1.70 silicon, 0.65 to 0.75 manganese, 0.40 phosphorus, 0.8 to 0.10 sulphur. While our carbons are not noted as a rule, we get a check on these every once in a while, showing the total carbons about 3.50 to 3.60. Our iron for smaller pieces runs from 1.80 to 1.90 in silicon, 0.40 to 0.50 in phosphorus, 0.65 to 0.70 manganese, 0.07 to 0.10 in sulphur. The total carbon shows up practically the same in both mixtures. Our test bars on the first mixture break at from 2800 to 3200 and on the latter mixtures at about 2600. This refers to 1 inch by 1 inch standard bars supported on 12-inch centers.

A Manufacturer of Grinding Machines: We use castings with various proportions of steel according to the size of the casting and the place where it is to be used, so that we have very bright lustrous surfaces.

Practice with Reference to Chilling Castings

There is a wide difference of opinion among machine tool manufacturers as to the desirability of chilling surfaces of castings. The writer asked some of the representative manufacturers of various classes of machine tools for their experience. The quotations state both sides of the case:

A Manufacturer of Milling Machines: We are not using any chills at this time, though we have experimented with these from time to time but have reached no satisfactory conclusion.

A Lathe Manufacturer: We have not used chills on any parts of our machines, which, we must concede, is from many points of view, not a very satisfactory admission to make.

A Manufacturer of Heavy Machine Tools: For quite a period, about nine or ten years ago, we chilled the ways on our lathes and also the rails on our boring mills. We found, however, after they had been out some time that there was considerable trouble owing to the chilled surfaces scratching. It was hard to find exactly the root of the trouble and we finally gave it up. The effect of the scratching of the chilled ways was a most peculiar one, and we sometimes observed on a machine, even before it had gone out, that some little particle of material had settled on the way and scratched it badly.

A Manufacturer of Grinding Machines: In regard to chilled iron, of course, you know that chilled iron means iron that cannot be filed, planed or scraped. At least any mechanic understands "chilled iron" to mean a surface that cannot be cut with tools. Now such a surface makes it impossible to get practical aligning ways on machine tools. It might just barely be possible to grind them accurately, but probably not practicable to do so. We use an iron with steel mixture, and vary the mixture according to the size of the casting, and we produce a casting as dense and as hard as we can possibly plane and scrape with any surety of getting perfect alignment, because imperfect bearing and imperfect alignment are just as bad as iron that is too soft.

Another Manufacturer of Grinding Machines: The main reason for chilling the different parts of our work is to increase the wearing durability and, at the same time, secure the advantage of refined metal and a clean surface. The parts chilled are the guides of the carriage and the surface of the table upon which the head and tailstocks are mounted. Our method of chilling is to place plates $\frac{5}{8}$ inch thick in the mold; these give a depth of chill of about $\frac{1}{2}$ inch and a degree of hardness to the point where the machining can be done readily. It would be natural to suppose that this chilling would produce or increase internal strains, but on our work, such conditions have not given any trouble.

Our work is not of such a nature that hammering upon it or peening is necessary; therefore, we are unable to state just what action would take place as the result of hammer blows and peening. The chilled surfaces are very much more durable than metal in the ordinary condition, and we believe by the chilling process, the durability of the surface upon which wear comes is increased at least from 300 to 400 per cent.

A Builder of Heavy Machine Tools: In 1888 we began the practice of solidifying cast-iron surfaces by introducing chill blocks in the molds, and we have continued the practice ever since. Answering your questions specifically, first, we have not discontinued the use of chilled surfaces because of any difficulty in oiling. We have never found that the fine grain of the chilled iron prevented the oil from sticking. There is no truth in the statement. We have not found any increase in internal strains due to the use of chills. On the contrary, when chills are properly placed they equalize the cooling of the heavy parts adjacent to lighter portions and reduce the internal stresses which would naturally result from the difference in time of cooling. If the chills are improperly used it would be possible, especially in thin castings, to cool the entire mass too rapidly and produce internal stresses. We have not found that the proper use of chills makes the iron more sensitive to a peening action; in fact, we have evidence to the contrary. The chilled surface we believe to be more durable. Gearing made in this way has outlasted several sets made in the old manner. The success or failure of this process depends upon the ability to produce, day in and day out, the kind of metal required, and, further, the intelligent designing of chills of iron molds so that a proper relation may always be observed between the size and shape of the casting and the thickness of the mold or chill block.

A Boring-Mill Manufacturer: We are chilling certain sur-

faces on our boring-mill spindles with good success, but have found no occasion for chilling any other surfaces. If we experienced difficulty due to undue wear on sliding surfaces, we would increase the area of the surfaces and supply better lubrication and protection from dirt rather than to try to chill the surfaces of these parts. The chills which we use on our spindles serve two purposes: First, by securing closer grained metal; second, by improving the quality of the wearing surfaces. We found that it was difficult to get good castings of these spindles until we used chills.

A Builder of Special Machine Tools: Concerning chills, we would say that to some extent we are now using these on the surfaces of beds and similar castings.

Chilled Lathe Beds

Analysis of Iron: In view of the considerable differences in opinions of the value of chilled surfaces and the idea held by some that it is impossible to chill an iron of high tensile strength without making it so hard that it cannot be machined, the practice of the Lodge & Shipley Machine Tool Co., with which the writer is connected, is here outlined.

Three average analyses are as follows:

Silicon	Sulphur	Phosphorus	Manganese	Tensile Strength
2.16	0.065	1.01	0.40	22,310
2.17	0.065	1.01	0.39	24,840
2.45	0.076	0.63	0.71	24,195

The first analysis is of a specimen taken in January, 1913, from the first iron run in a heat; the second, from the last iron of the same heat; the third, from the average iron of a heat in September, 1913. This iron is used for lathe beds of which the ways are chilled; it is also used for other cast-iron parts which do not require the high tensile strength of semi-steel. For parts, such as compound rest top slides and reverse plates, we use semi-steel. Parts subject to greater stress or to severe shock are made of steel.

A cross-sectional fracture through the finished ways and a portion of the side wall of a chilled bed for a 30-inch lathe, clearly shows that the iron, even far away from the chill in the side wall of the casting, is dense and of as close grain as other good cast iron; it also shows the much closer grain of the iron below the finished surface, as a result of the chill in closing up the iron and making it harder and more durable. In the 30-inch bed, the close iron produced by the chill extends to a depth of 1½ inch to 2 inches below the finished surface of the ways, thus proving that the chilled iron is not all removed in the planing.

Degree of Hardness

Scleroscope tests on chilled beds finish-planed but not scraped, gave as a result of eight different tests on four different beds, scleroscope readings of 40 to 42 with an average of 41. Similar tests on chilled beds which had been planed and then scraped gave a practically constant scleroscope reading of 42. Comparative scleroscope tests on a heavy section of unchilled cast iron which would give as nearly as possible conditions parallel to those just quoted gave readings ranging from 18 to 22, with an average of 20.

In addition to the advantage gained by the hardness, the chilled beds are, if anything, more uniform than the unchilled. The rough beds as received from the foundry are quite straight, so that the amount of metal removed all along the ways in planing is as nearly uniform as is practicable. Then, too, the scleroscope readings indicated a more nearly constant degree of hardness on the chilled beds than on the unchilled. Fewer castings are unsound than before chills were used.

Action of the Chill

The chilled surface is produced by a series of cast-iron chill plates, each about 6 inches long, placed end to end in the mold. The use of separate short plates eliminates much of the warping and twisting which would occur in a long chill plate. If a thick chill plate is used with a low-silicon iron, the surface of the casting is chilled so hard that it cannot be machined. The desired result is attained by regulating the thickness of the chill plate to suit the size of the casting for which it is used; then a low-silicon iron of high tensile strength can be poured successfully. The heavier the casting, the thicker the chill plate. The action in the mold is that when the molten iron strikes the cold plate it is chilled and hardened; then the heat in the mass of iron forming the body of the bed casting gradually warms the chilled surface and the chill plate, thus annealing the casting or "drawing the chill," just as when in tempering a chisel, the heat in the shank of the chisel "draws the temper" of the cutting edge to the proper point after the cutting edge has been hardened by quenching in water. This annealing of the chilled surface of the casting produces the desired form of hard, close-grained gray iron. The thickness of the chill plate used is such that the heat in the casting will anneal the surface sufficiently to permit planing, although at a greatly reduced cutting speed, and yet retain the benefits of the chill.

Value of Chilled Surfaces

The advantages of chilled wearing surfaces for machine tools are:

1. Much harder surfaces, which experience has proved are vastly more durable than similar unchilled surfaces.
2. A hard guiding surface with a relatively soft carriage, bringing the bulk of the wear on the carriage and thus maintaining the alignment of the guide.
3. A denser and much more closely grained surface of the casting, giving better appearance.
4. An exceptionally smooth finished surface, in which there are no pores where dirt and grit may become imbedded to cause rapid abrasion of the other bearing surface.

There are several ways of increasing the durability of working parts, such as by increasing the area of the bearing, by providing more complete lubrication, and by hardening the surfaces. All are successfully used. In general, each method may be used independently of the others. If the areas of the surfaces are as large as special conditions permit, and if the lubrication is thoroughly efficient, there would seem to be no objection to still further increasing the durability by the use of chills. Chilled surfaces are more advantageous on some machines and some parts than on others. In the case of a lathe the carriage will often be used for long periods of time on chuck work or on short jobs between centers which brings all of the wear on a comparatively short length of the bed just in front of the headstock; such uneven wear on the unchilled bed destroys the accuracy of the alignment for long work. Chilling the ways brings the wear principally upon the carriage, and even if the carriage is worn, the alignment at all points along the bed will remain relatively true.

Only one manufacturer of all who were kind enough to reply on this subject, had discontinued the use of chills; the others who are using chills do not report any trouble due to scratching. The objections to the use of chills, aside from the one instance quoted, have come from foundrymen who do not and have not used chills. Our own experience, based on the use of chilled ways on beds of all sizes of our lathes for more than two years, is that no internal stresses are created by the chilling; that the surface is not made more susceptible to a peening action; that the surface can be equally as well lubricated as before; that iron of high tensile strength is used; and that the increased hardness and closeness of grain of the chilled surface vastly increases the durability and permanency of alignment. We find no disadvantage except a somewhat increased cost.

Tensile Strengths of Various Irons

As the letters received from other machine tool manufacturers do not state tensile strengths, the following statements regarding the general practice of Cincinnati manufacturers are quoted:

A Professor of Mechanical Engineering and Testing: I believe the general Cincinnati machine tool practice for good castings runs from 22,000 to 24,000 pounds per square inch, tensile strength, but owing to the great variety I would not wish to commit myself to any particular figures.

A Cincinnati Chemist: After tabulating the results of my tests of the tensile strength of cast iron from various sources, I pick some at random to show the average run of machine tool iron in pounds per square inch in this locality: 22,962; 24,090; 24,522; 23,197; 23,260.

This will give an idea of what the general run is. Good machineable iron, where the grain does not have to be too close for machine tool work, should run from 20,000 to 26,000 pounds per square inch. Low tensile strength is due to too much silicon, sulphur, or phosphorus.

PRINCIPLES OF BAND-BRAKE DESIGN*

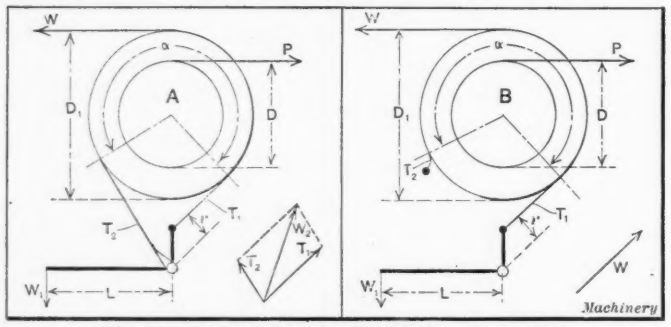
FORMULAS AND DATA WHICH SIMPLIFY THE CALCULATIONS INVOLVED

BY G. M. DAHL†

The purpose of this article is to deal very briefly with the fundamental principles of band-brake design. The brakes considered are classified under two general headings: 1, single-acting brakes, the most important feature of which is that they are good lowering brakes; 2, differential brakes, the most important feature of which is that they are good holding brakes but are liable to give a jerky lowering action, especially when the ratio $\frac{r}{r_1}$ is close to the locking ratio. Bearing in mind the features of these two classes of band-brakes, it will be evident that a single-acting brake should be used when a safe and steady lowering of the load is essential, but when the object is simply to hold a heavy load, a differential brake will be found most satisfactory. It must not be inferred from this statement that a single-acting brake cannot be made to hold a heavy load. From the formula,

$$\frac{L}{r} = \frac{FW}{W_1}$$

it will be easily seen that it is merely a question of making



Figs. 1 and 2. Single-acting Band-brakes; A, One End Loose on Shaft; B, One End Fastened

the ratio $\frac{L}{r}$ sufficiently large, and when this is done any kind of brake can be made to hold the required load. The ratio $\frac{L}{r}$ will, however, be limited by practical considerations in most cases of band-brake design.

Another important consideration is the bending stress on the drum-shaft that is produced by setting the brake. The bending stress on the brake-shaft is not of such importance because the brake-shaft can easily be supported by brackets on the bed plate of the hoist, thus reducing the bending moment to a minimum. In the case of the drum-shaft, however, this cannot be effected without considerably increasing the cost of the hoist and complicating its design. It is therefore essential to reduce the bending stress on the drum-shaft to a minimum. This result is obtained by increasing the arc of contact and the coefficient of friction, and also by locating the brake-shaft in such a way that the resultant bending stress produced by the brake acts in the opposite direction to the rope pull. Even though the location of the brake-shaft may be determined by the general design of the hoist, it is always well to remember that the location of the shaft within these fixed limits is a matter of importance.

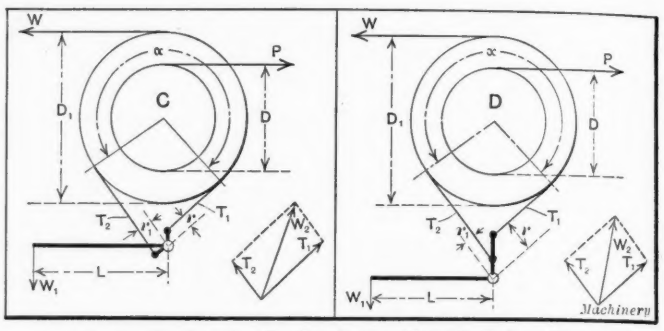


Fig. 3. Single-acting Band-brake C with Both Ends pulling.

Fig. 4. Differential Band-brake D

In order t ofacilitate calculations in the design of band-brakes, the following formulas are given:

$$F = \frac{W_1 \frac{L}{r}}{W} \quad (1)$$

$$W = \frac{W_1 \frac{L}{r}}{F} \quad (2)$$

$$W_1 = \frac{FW}{\frac{L}{r}} \quad (3)$$

$$\frac{L}{r} = \frac{FW}{W_1} \quad (4)$$

Examples illustrating the use of these formulas are given in subsequent paragraphs, which make the method of procedure quite clear. Figs. 1, 2 and 3 show different arrangements of single-acting band-brakes, while Fig. 4 illustrates the differential type of band-brake. The following explains the notation used in these illustrations:

TABLE I. VALUES OF CONSTANT FOR BAND BRAKE DESIGN

Arc of Contact, Deg.	C	f = 0.18				f = 0.30				f = 0.35				f = 0.57			
		N	T_2	T_1	A Sq. Ins.	N	T_2	T_1	A Sq. Ins.	N	T_2	T_1	A Sq. Ins.	N	T_2	T_1	A Sq. Ins.
220	1.667	2.00	2.000	1.000	0.000250	3.16	1.463	0.463	0.000183	3.83	1.352	0.352	0.000169	8.91	1.126	0.126	0.000141
230	1.746	2.06	1.943	0.943	0.000243	3.34	1.427	0.427	0.000178	4.08	1.325	0.325	0.000166	9.82	1.113	0.113	0.000139
240	1.820	2.12	1.893	0.893	0.000237	3.52	1.397	0.397	0.000174	4.34	1.299	0.299	0.000163	10.88	1.101	0.101	0.000138
250	1.894	2.19	1.840	0.840	0.000230	3.70	1.370	0.370	0.000171	4.60	1.278	0.278	0.000160	12.02	1.091	0.091	0.000136
260	1.970	2.26	1.794	0.794	0.000224	3.90	1.345	0.345	0.000168	4.89	1.257	0.257	0.000157	13.27	1.082	0.082	0.000135
270	2.046	2.33	1.752	0.752	0.000219	4.11	1.322	0.322	0.000166	5.21	1.238	0.238	0.000154	14.66	1.073	0.073	0.000134
280	2.124	2.41	1.709	0.709	0.000214	4.34	1.299	0.299	0.000163	5.54	1.220	0.220	0.000153	16.24	1.066	0.066	0.000133
290	2.200	2.49	1.671	0.671	0.000209	4.57	1.280	0.280	0.000160	5.88	1.205	0.205	0.000151	17.94	1.059	0.059	0.000132
300	2.275	2.57	1.636	0.636	0.000204	4.81	1.262	0.262	0.000158	6.25	1.190	0.190	0.000149	19.78	1.054	0.054	0.000132
310	2.349	2.65	1.606	0.606	0.000201	5.07	1.246	0.246	0.000156	6.64	1.177	0.177	0.000147	21.88	1.048	0.048	0.000131
320	2.425	2.73	1.578	0.578	0.000197	5.34	1.230	0.230	0.000154	7.06	1.165	0.165	0.000146	24.18	1.043	0.043	0.000130
330	2.500	2.82	1.549	0.549	0.000194	5.63	1.216	0.216	0.000152	7.52	1.153	0.153	0.000144	26.70	1.039	0.039	0.000130
340	2.576	2.91	1.524	0.524	0.000190	5.93	1.203	0.203	0.000150	7.99	1.143	0.143	0.000143	29.50	1.035	0.035	0.000129

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P = rope pull in pounds = $\frac{WD_1}{D}$;

W = load on brake ring in pounds = $\frac{PD}{D_1}$;

D = diameter of rope circle in inches = $\frac{WD_1}{P}$;

* For further information on the subject of band brake design, see "Band and Block Brakes," by A. L. Campbell, published in MACHINERY, October, 1908; "Friction Brakes," by H. D. James, August, 1908; "Brakes," by C. F. Blake, August, September, October and November, 1906; and "Notes on Band Brake Design," by C. F. Blake, March, 1905.

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D_1 = diameter of brake ring in inches $= \dfrac{PD}{W}$;

r = distance from center of brake-shaft to slack side of brake-band in inches $= \dfrac{W_1 L}{FW}$;

r_1 = distance from center of brake-shaft to taut side of brake-band in inches;

L = length of brake-lever in inches $= \dfrac{FrW}{W_1}$;

F = force required at radius r to hold a load W of 1 pound on the brake ring;

$F = T_1$ for a nsigle-acting brake with one end pulling;

$F = T_1$ for a single-acting brake with one end pulling;

$F = T_1 - \dfrac{T_2}{\frac{r}{r_1}}$ for differential brakes;

T_1 = tension in slack end of band in pounds $= \dfrac{W}{N-1}$
$= T_2 - W$;

T_2 = tension in taut end of band in pounds $= \dfrac{WN}{N-1}$
$= W + T_1$;

W_2 = load on brake-shaft in pounds. This quantity is the resultant of T_1 and T_2 which is shown graphically in the illustration of the different styles of brakes.

$N = \dfrac{T_2}{T_1}$ = locking ratio of $\dfrac{r}{r_1}$. The ratio $\dfrac{r}{r_1}$ must be at least 1.5 N to prevent differential brakes from locking themselves. Log $N = Cf$. Values of the constant C for various arcs of contact and coefficients of friction are given in Table I.

f = coefficient of friction. For maple in contact with cast iron, the coefficient of friction $f = 0.18$; for a 75-degree V-brake with plain maple blocks, $f = 0.30 = \text{cosecant} \dfrac{75 \text{ degrees}}{2} \times f = 1.6427 \times 0.18 = 0.296$; for cork on cast iron $f = 0.35$; for a 75-degrees V-brake with cork inserts $f = 0.57$.

A = minimum area of cross-section of wrought iron brake-band in square inches calculated for a fiber stress of 8000 pounds per square inch. This value of the fiber stress ought not to be exceeded for wrought-iron brake-bands.

The values of T_1 and T_2 and A are given in Table I for a load W of one pound on the brake ring. For any other load, the values given in the table are multiplied by that load. The force F required at a radius r to hold a load W of one pound on the brake ring is given in Tables II, III and IV, for different arcs of contact, coefficients of friction, and ratios $\dfrac{r}{r_1}$ for differential brakes. For any other arc of contact or ratios $\dfrac{r}{r_1}$, it will be accurate enough to interpolate between the values given in the table, although it is not strictly correct. It is important to observe at this point that it is not advisable to interpolate for coefficients of friction lying between the values given in the table.

In order to illustrate the use of the formulas and tables presented in this article, the following problems are worked out. These problems cover the different cases which may occur in band-brake design.

Example 1. To determine the most suitable style of brake to use for a given class of service. Consider a case in which the brake-ring load $W = 30{,}000$ pounds; the brake-lever load $W_1 = 150$ pounds; the ratio $\dfrac{L}{r} = 20$; and the arc of contact $= 280$ degrees. For these conditions:

$$F = \frac{W_1 \frac{L}{r}}{W} = \frac{150 \times 20}{30{,}000} = 0.10.$$

The only suitable brakes for this case are found in Tables

TABLE II. VALUES OF F FOR SINGLE-ACTING BAND BRAKES

Style of Brake	f	Arc of Contact in Degrees												
		220	230	240	250	260	270	280	290	300	310	320	330	340
Both ends pulling	0.18	3.000	2.886	2.786	2.680	2.588	2.504	2.418	2.342	2.272	2.212	2.156	2.098	2.048
	0.30	1.926	1.854	1.794	1.740	1.690	1.644	1.598	1.560	1.524	1.492	1.460	1.432	1.406
	0.35	1.704	1.650	1.598	1.556	1.514	1.476	1.440	1.410	1.380	1.354	1.330	1.306	1.286
	0.57	1.252	1.226	1.202	1.182	1.164	1.146	1.132	1.118	1.108	1.096	1.086	1.078	1.070
One end pulling	0.18	1.000	0.943	0.893	0.840	0.794	0.752	0.709	0.671	0.636	0.606	0.578	0.549	0.524
	0.30	0.463	0.427	0.397	0.370	0.345	0.322	0.299	0.280	0.262	0.246	0.230	0.216	0.203
	0.35	0.352	0.325	0.299	0.278	0.257	0.238	0.220	0.205	0.190	0.177	0.165	0.153	0.143
	0.57	0.126	0.113	0.101	0.091	0.082	0.073	0.066	0.059	0.054	0.048	0.043	0.039	0.035

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TABLE III. VALUES OF F FOR DIFFERENTIAL BAND BRAKES

	f = 0.18												f = 0.30										
$\frac{r}{r_1}$	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	5.50	5.00	5.50	6.00	6.25	6.50	6.75	7.00	7.50	8.00	8.50	9.00	10.00
Arc of Contact, Deg.																								
220	.200	.273	.333	.385	.429	.467	.500	.529	.556	.579	.600	.636	.170	.197	.219	.229	.238	.246	.254	.268	.280	.291	.300	.317
230	.165	.236	.295	.344	.387	.425	.457	.486	.511	.534	.554	.590	.142	.163	.189	.199	.208	.216	.223	.237	.249	.259	.268	.283
240	.135	.205	.262	.311	.352	.388	.419	.448	.473	.494	.514	.549	.117	.142	.163	.173	.181	.189	.196	.210	.222	.232	.241	.256
250	.104	.171	.227	.274	.315	.350	.381	.409	.432	.454	.473	.490	.096	.121	.142	.151	.159	.167	.174	.187	.199	.209	.218	.233
260	.076	.141	.196	.242	.281	.316	.346	.372	.395	.416	.435	.452	.077	.101	.121	.131	.139	.146	.153	.166	.178	.188	.197	.211
270	.051	.114	.164	.213	.251	.284	.313	.339	.362	.382	.401	.418	.058	.083	.102	.111	.119	.127	.134	.147	.158	.167	.176	.191
280	.023	.087	.139	.183	.221	.254	.282	.307	.330	.350	.368	.398	.040	.064	.084	.092	.100	.107	.114	.127	.137	.147	.156	.170
290	.001	.063	.114	.157	.194	.226	.253	.280	.300	.319	.337	.367	.025	.048	.068	.076	.084	.091	.098	.110	.121	.130	.139	.153
300	.....	.041	.091	.133	.179	.200	.228	.251	.273	.292	.309	.339	.011	.034	.053	.062	.069	.077	.083	.095	.106	.115	.124	.138
310	.....	.022	.071	.112	.147	.178	.205	.228	.249	.268	.285	.314	.....	.019	.038	.046	.054	.061	.068	.080	.090	.099	.108	.121
320	.....	.003	.051	.091	.126	.156	.182	.206	.226	.244	.261	.291	.....	.007	.026	.034	.042	.049	.055	.067	.077	.086	.094	.108
330	.....	.....	.033	.072	.106	.135	.161	.184	.204	.223	.239	.267	.....	.....	.012	.021	.028	.035	.041	.053	.063	.072	.080	.093
340	.....	.....	.015	.054	.088	.117	.142	.165	.184	.202	.218	.246	.....	.....	.....	.010	.018	.025	.031	.043	.053	.061	.069	.083

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II, III and IV, for an arc of contact of 280 degrees, and $F = 0.10$. In Table II, for a single-acting V-brake with cork inserts and one end pulling, $f = 0.57$ and $F = 0.066$. This brake will hold the load with a load on the brake-lever:

$$W_1 = \frac{FW}{\frac{L}{r}} = \frac{0.066 \times 30{,}000}{20} = 99 \text{ pounds}$$

By making the load on the brake-lever $W_1 = 150$ pounds, the load can be held by proportioning the brake mechanism so that ratio $\frac{L}{r} = \frac{FW}{W_1} = \frac{0.066 \times 30{,}000}{150} = 13.2$. Referring to Table I, for an arc of contact of 280 degrees and a coefficient of friction $f = 0.57$, the value of A is found to be 0.000133. Multiplying this value by 30,000 for the case under consideration, the minimum cross-sectional area of the brake-band is found to be $0.000133 \times 30{,}000 = 3.99$ square inches. It is evident that a single-acting band-brake with both ends pulling cannot be used in this case because the minimum value of F for $f = 0.57$ is found to be 1.132, which is greater than the previously determined maximum value of 0.10.

Next consider the case of a differential brake in which $F = 0.10$; $f = 0.18$ and $\frac{r}{r_1} = 2.8$. The ratio $\frac{r}{r_1}$ is seen to be too close to the locking ratio 2.41 given in Table I, for it will be remembered that the value of this ratio for differential brakes must be at least 1.5 times the locking ratio in order to prevent the brake from locking itself. For a brake with $F = 0.10$, $f = 0.30$ and $\frac{r}{r_1} = 6.5$, the locking ratio given in Table I is found to be 4.34. This brake may be used, as the ratio $\frac{r}{r_1} = 6.5 = 1.5 \times 4.34$. The value of A in Table I is found to be 0.000163. Multiplying this value by 30,000 gives $0.000163 \times 30{,}000 = 4.89$ square inches, as the minimum cross-sectional area of the brake-band. For a differential brake with $F = 0.10$, $f = 0.35$ and $\frac{r}{r_1} = 11.0$, the locking ratio given in Table I is 5.54. This brake may be used, as the ratio $\frac{r}{r_1}$ is greater than 1.5 times the locking ratio. The value of A given in Table I is found to be 0.000153. Multiplying this coefficient by the load gives $0.000153 \times 30{,}000 = 4.59$ square inches as the minimum value of the cross-sectional area of the brake-band.

TABLE V. RESULTS OF VARYING ARC OF CONTACT AND COEFFICIENT OF FRICTION

f	0.18	0.30	0.35	0.57
For Arc of Contact of 220 Degrees				
T_1 in pounds	10,000	4630	3520	1260
T_2 in pounds	20,000	14,630	13,520	11,260
Bending force in pounds	28,200	18,300	16,400	12,150
For Arc of Contact of 320 Degrees				
T_1 in pounds	5780	2300	1650	430
T_2 in pounds	15,780	12,300	11,650	10,430
Bending force in pounds	11,900	10,700	10,500	9800

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TABLE VI. VALUES OF W_1 IN POUNDS FOR DIFFERENT ANGLES OF CONTACT AND COEFFICIENTS OF FRICTION

	Arc of Contact, Deg.	f = 0.18	f = 0.30	f = 0.35	f = 0.57
Single-acting brake with one end pulling	220	500	232	176	63
	320	289	115	83	21
Single-acting brake with both ends pulling	220	1500	963	852	626
	320	1078	730	665	539
Differential brake with the ratio $\frac{r}{r_1} = 1.5\ N$.	220	166	85	55	19
N = locking ratio	320	95	39	26	7

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TABLE IV. VALUES OF F FOR DIFFERENTIAL BAND BRAKES

	f = 0.35										f = 0.57											
$\frac{r}{r_1}$	5	6	7	8	9	10	11	12	13	20	10	15	18	20	22	24	26	28	30	35	40	80
Arc of Contact, Deg.																						
220	0.082	0.125	0.159	0.183	0.202	0.217	0.229	0.239	0.248	0.285	0.014	0.052	0.064	0.071	0.076	0.080	0.084	0.087	0.089	0.095	0.099	0.113
230	0.060	0.104	0.136	0.159	0.179	0.192	0.205	0.215	0.223	0.259	0.002	0.040	0.052	0.058	0.063	0.067	0.071	0.074	0 076	0.081	0.085	0.099
240	0.040	0.083	0.113	0.137	0.155	0.170	0.182	0.191	0.200	0.235	.....	0.028	0.040	0.046	0.051	0.055	0.059	0.062	0 064	0.070	0.074	0.087
250	0.022	0.065	0.096	0.118	0.136	0.150	0.162	0.172	0.180	0.214	....	0.017	0.029	0.035	0.040	0.045	0.048	0.052	0.054	0.059	0.063	0.076
260	0.005	0.047	0.077	0.099	0.116	0.129	0.142	0.151	0.159	0.193	.....	0.010	0.022	0.028	0.033	0.037	0.040	0.043	0.046	0.051	0.055	0.069
270	.....	0.029	0.059	0.081	0.098	0.111	0.123	0.132	0.140	0.173	.....	0.002	0.014	0.020	0.025	0.029	0.033	0.036	0.038	0.043	0.047	0.061
280	.....	0.017	0.046	0.067	0.085	0.098	0.109	0.118	0.126	0.159	.....	.....	0.006	0.012	0.017	0.021	0.024	0.027	0.030	0.035	0.038	0.052
290	.....	0.004	0.033	0.054	0.071	0.084	0.095	0.104	0.112	0.145	.....	....	....	0 006	0.011	0 015	0.018	0.021	0.024	0.029	0.032	0.046
300	.....	.....	0.021	0.042	0.059	0.072	0.083	0.092	0.099	0.131	.....	.....	.....	0 001	0.006	0.010	0.013	0.016	0.019	0.024	0.027	0.040
310	.....	.....	0.010	0.031	0.049	0.060	0.071	0.080	0.087	0.120	.....	.....	.....	.....	....	0.004	0.008	0.011	0.013	0.018	0.022	0.035
320	.....	.....	.....	0.019	0.035	0.048	0.059	0.068	0.075	0.107	.....	.....	.....	.....	.....	.....	0.003	0.006	0.008	0.013	0.017	0.030
330	.....	.....	.....	0.009	0.024	0.038	0.048	0.057	0.064	0.095	.....	.....	.....	.....	.....	.....	.....	0.002	0.004	0.009	0.013	0.026
340	.....	....	....	0.002	0.018	0.030	0.041	0.050	0.057	0.088	.....	....	....	....	.....	.....	.....	....	0.001	0.005	0.009	0.022

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Example 2. For a given brake, to determine the load that may be held on the brake ring with a given load on the lever. Consider the case of a single-acting V-brake with both ends pulling, arc of contact 260 degrees; $\frac{L}{r} = 25$; $W_1 = 100$ pounds; $f = 0.30$. Referring to Table II, the value of F is found to be 1.69. The load that can be held is:

$$W = \frac{W_1 \frac{L}{r}}{F} = \frac{100 \times 25}{1.69} = 1480 \text{ pounds}$$

The value of A in Table I is found to be 0.000168. Multiplying this value by the load gives $1480 \times 0.000168 = 0.249$ square inches as the minimum cross-sectional area of the brake-band.

Example 3. For a given brake, to determine the load required on the lever to hold a specified load on the brake ring. As an example, consider a single-acting brake with one end pulling; arc of contact 270 degrees; coefficient of friction $f = 0.35$; ratio $\frac{L}{r} = 20$; $W = 12{,}000$ pounds. Referring to Table II, we find $F = 0.238$.

$W_1 = \frac{FW}{\frac{L}{r}} = \frac{0.238 \times 12{,}000}{20} = 143$ pounds. The value of the coefficient A given in Table I is found to be 0.000154. Multi-

plying this value by the load gives $0.000154 \times 12{,}000 = 1.848$ square inches as the minimum cross-sectional area for the brake-band.

Example 4. For a given brake, to determine the value of the ratio $\frac{L}{r}$ that is necessary to hold a specified load on the brake ring with a given load on the brake-lever. Consider the case of a differential brake with the ratio $\frac{r}{r_1} = 5$; the coefficient of friction $f = 0.18$; the arc of contact $= 290$ degrees; the load on the brake ring $W = 15{,}000$ pounds. The load on the brake-lever $W_1 = 150$ pounds. Referring to Table III, we find $F = 0.337$. The ratio is then found to be:

$$\frac{L}{r} = \frac{FW}{W_1} = \frac{0.337 \times 15{,}000}{150} = 33.7$$

The coefficient A found in Table I is 0.000209. Multiplying this value by the load gives $0.000209 \times 15{,}000 = 3.135$ square inches, as the minimum value of the cross-sectional area for the brake-band.

In order to show the effect of changing the arc of contact and coefficient of friction, Tables V and VI have been prepared for two brakes with arcs of contact of 220 and 320 degrees, respectively, and coefficients of friction ranging from 0.18 to 0.57. The load on the brake ring W is 10,000 pounds and the ratio $\frac{L}{r}$ is 20. The values of T_1 and T_2 are obtained from Table I, the values of the coefficients obtained from this table being multiplied by 10,000 in order to secure the correct values for the case under consideration. The bending force on the brake-shaft produced by setting the brake is found by constructing a parallelogram of forces on T_1 and T_2 to some convenient scale. The resultant of this parallelogram is the required bending force.

The method of calculating the load required on the brake lever has already been illustrated by following through a problem. In Table VI values of the brake-lever load W_1 have been calculated for the two brakes referred to in the preceding paragraph, for arcs of contact of 220 and 320 degrees, respectively, and coefficients of friction f ranging from 0.18 to 0.57. It will be readily seen from these results that a single-acting brake with both ends pulling is a very poor holding brake. It will also be seen that for a single-acting brake with one end pulling, the load required on the brake lever varies from 500 to 21 pounds as the result of increasing the arc of contact from 220 to 320 degrees, and increasing the coefficient of friction from 0.18 to 0.57. Of course the figures in Tables V and VI give a somewhat exaggerated idea of the difference between good and poor examples of band-brake design, but they emphasize the point that it is possible to materially reduce the strains and increase the holding power of the brake by proportioning its members properly.

By way of conclusion, the following may be said to constitute the underlying principles of band-brake design. Make the arc of contact as large as possible; locate the brake-shaft where the bending stress in the drum-shaft produced by setting the brake is counteracted by the rope pull; and, if necessary, increase the coefficient of friction to give the required holding power.

CALCULATION OF STRESSES IN AUTOMOBILE FRONT AXLES

BY JOHN L. ALDEN*

Automobile front axles are made of steel or bronze forgings, steel castings, or steel tubing, although bronze is seldom used except for emergency or experimental purposes. Steel castings are frequently used for truck axles, but axles of this material are seldom found in pleasure cars to-day. Steel tubing was also one of the favorite materials of the earlier designers, and is still successfully used on many light- and medium-weight cars. It has the advantage of being readily obtainable in its finished form, needs little or no machining, and the only forgings required are those for the steering heads and spring seats. By far the greater number of pleasure cars in operation to-day carry drop-forged front axles, and thus far no other type has even threatened their supremacy. Both carbon and alloy steels are being used with success. Carbon steels of 0.25 to 0.30 per cent have an elastic limit of from 40,000 to 80,000 pounds per square inch when heat-treated according to the recommendation of the Society of Automobile Engineers. Steel of this character may be allowed a fiber stress of 10,000 pounds per square inch, but this value may be safely raised to 15,000 pounds per square inch if the specifications are rigidly adhered to and if great care is taken in the forging and heat-treatment. The elastic limit of 0.30 to 0.35 per cent carbon nickel steel lies between 65,000 and 160,000 pounds per square inch when the S. A. E. recommendations are followed. Chrome-nickel steel with 0.25 to 0.40 per cent carbon has an elastic limit ranging from 50,000 to 125,000 pounds per square inch for low chrome-nickel and from 65,000 to 200,000 pounds per square inch for high chrome-nickel steel. The elastic limit of 0.25 to 0.45 per cent carbon, chrome-vanadium steel may vary from 55,000 to 200,000 pounds per square inch. Any of these alloy steels are suitable for structural drop-forgings, and when used for axles, an average working stress of 15,000 pounds per square inch, with a limit of 20,000 for exceptionally favorable conditions, is allowable. The lower value is more suitable for cars for quantity production or for any case where the greatest care cannot be taken in manufacture, as under these circumstances, the elastic limit of the material will be found to be in the neighborhood of the lower figures given for the metal under consideration.

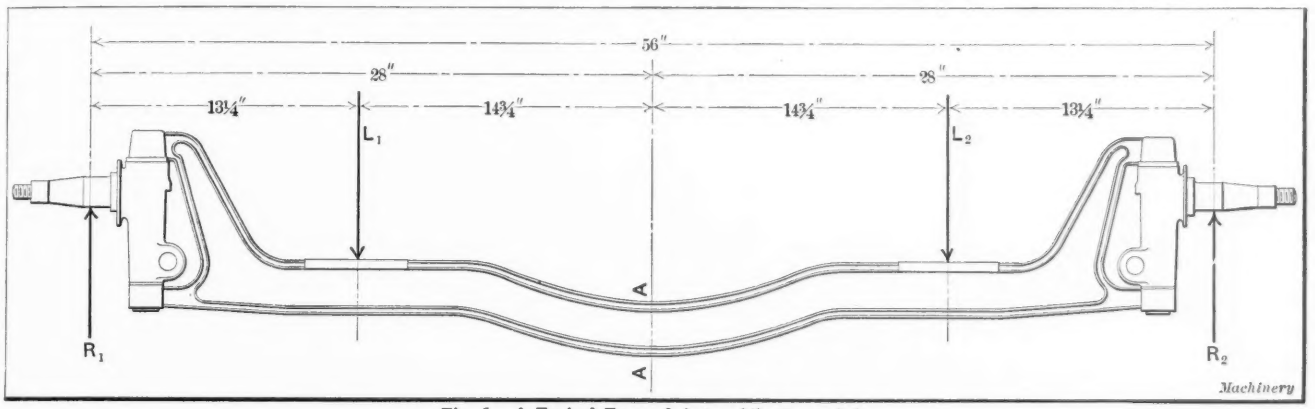

Fig. 1. A Typical Form of Automobile Front Axle

A typical front axle for a pleasure car is shown in Fig. 1. This is a drop-forging of an I-section similar to the one outlined in Fig. 2. The design shown is that of a well-known make equipped with Elliott type steering heads, and with the spring seats forged integral with the upper flange of the section. The I-shape is carried uniformly from spring seat to spring seat, as the bending moments due to the spring loads are equal at all points from L_1 to L_2. The top flange is flared from the width of the steering head bosses to the full width of the spring seat. When the car is in motion there are two sets of independent forces acting upon the axle—those caused by the weight of the car and those caused by the resistance of the road, due to striking obstacles, etc. The former are obviously vertical in direction, while the latter

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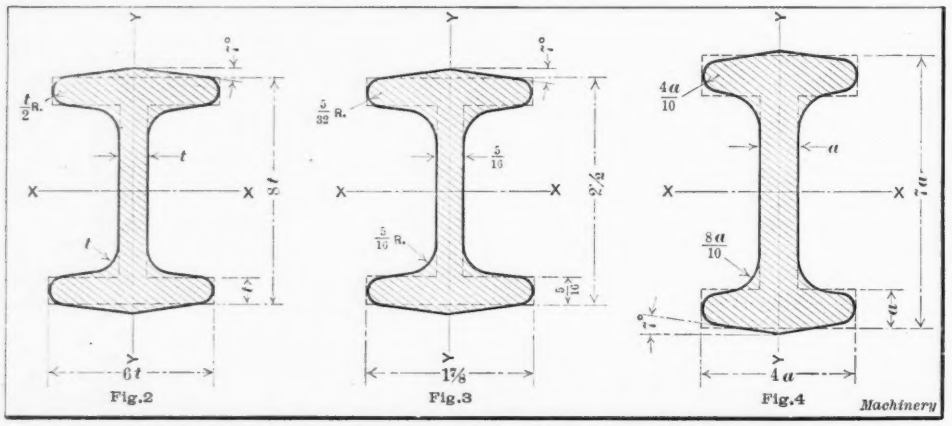
have both vertical and horizontal components. It is evident that the maximum horizontal force which the axle will be called upon to resist is indeterminate. The same is true of the vertical component of the collision force. The factors upon which this force depends are the velocity of the car, the size and shape of the obstruction, the depression of the tire due to impact, and the unsprung weight of the axle, wheels, etc. The determination of the horizontal resisting moment of the axle is, therefore, largely a matter of judgment and experience on the part of the designer. Any calculation of the vertical resisting moment must also be incomplete, since we have no means of determining the limiting value of the collision force. If we calculate our section to carry the static load of the vehicle, using the values for the allowable fiber stress previously given, we will be sure of a reasonable result, as the large factor of safety is expressly intended to cover the stresses which we are unable to estimate. Consequently, if we select a section whose proportions have proved satisfactory in actual service, we will not go far wrong in the relation between our horizontal and vertical resisting moments. The section shown in Fig. 2 is an average of a number of successful designs used on modern cars, covering a wide range of weight, speed and price. Therefore, if the section of Fig. 2 is selected and we calculate its dimensions, using the spring seat loads, we may expect to be reasonably close to modern practice. We will now assume the necessary data and carry through a typical example, in which we shall consider the axle as a simple beam, supported at the wheel centers and symmetrically loaded at the spring seats.



Figs. 2, 3 and 4. Two Forms of Sections used for Automobile Front Axles

We will consider the case of a 3600-pound touring car which, when loaded with five passengers, will weigh about 4350 pounds. In general, about 0.4 of the weight of a pleasure car is borne on the front axle, one-half of this being carried by each front spring. Thus the front axle load of our hypothetical car is $0.4 \times 4350 = 1740$ pounds and the load at each spring seat is 870 pounds. As the weight of the axle itself rarely exceeds 80 or 85 pounds, we may safely neglect this item. The principal dimensions will be assumed to be as given in Fig. 1. The statement has already been made that the bending moment due to the static load is maximum and equal at all points from L_1 to L_2. Hence the critical section may be chosen anywhere between the spring seats. Then, taking our section at A–A, we have the maximum bending moment:

$M_a = 28 \times 870 - 14.75 \times 870 = 13.25 \times 870 = 11{,}528$ inch-pounds.

Using the formula for beams:

$$M = SZ$$

where M = maximum bending moment;

S = fiber stress due to the maximum bending moment;

Z = the section modulus.

We may solve for Z and the dimensions of the section, providing we assume a suitable fiber stress. Let us assign to S a value of 10,000 pounds per square inch. Then our flexure equation, when transposed, becomes:

$$Z = \frac{M}{S} = \frac{11{,}528}{10{,}000} = 1.15.$$

Returning now to our average section, Fig. 2, it will be found much more simple and sufficiently accurate to base our calculations upon the equivalent section whose outline is shown dotted. The moment of inertia about the axis X–X is:

$$I_x = \frac{6t \times (8t)^3 - 2 \times 2.5t \times (6t)^3}{12} = 166\,t^4$$

$$Z_x = \frac{166\,t^4}{4t} = 41.5\,t^3$$

In the same manner:

$$I_y = \frac{2t \times (6t)^3 + 6t \times t^3}{12} = 36.5t^4$$

$$Z_y = \frac{36.5\,t^4}{3t} = 12.2t^3$$

$$\frac{Z_x}{Z_y} = \frac{41.5t^3}{12.2\,t^3} = 3.41$$

This signifies that the axle is 3.41 times as strong vertically as horizontally. The Z_x of our typical section is, according to the preceding calculations, $41.5\,t^3$; and the required value of Z_x of our axle is 1.15. Equating these, we have:

$$41.5\,t^3 = 1.15$$

$$t^3 = \frac{1.15}{41.5} = 0.0277.$$

$t = 0.3025$ inch or, to the nearest fraction, 5/16 inch.

From the value for t thus obtained all other dimensions for the section may be readily found. These are given in Fig. 3 for the case just discussed. By using these proportions, with the known section modulus, the cut-and-try methods commonly used are eliminated. It is evident that the calculations are thus much simplified.

Another section at one time in common use is shown in Fig. 4. The moments of inertia and section moduli are:

$$I_x = 83.1\,t^4; \qquad Z_x = 23.75\,t^3$$
$$I_y = 11.1\,t^4, \qquad Z_y = 5.56\,t^3$$
$$\frac{Z_x}{Z_y} = 4.27$$

This axle is, therefore, weaker in a horizontal plane than the one shown in Fig. 2. This would seem reasonable, as the horizontal force is due largely to shock and is proportional to the square of the velocity. Consequently, as the speed requirements increase, so should the horizontal resisting moment of the axle increase, which accounts for the gradual strengthening in this direction from year to year.

* * *

WOODEN SHOES MADE IN THE UNITED STATES

In this country beech is the favorite material for wooden shoes, the manufacture of which has reached considerable proportions in the United States according to the Department of Agriculture, which has just issued a bulletin on the use of the wood. These shoes, the department says, cost from sixty to seventy-five cents a pair and are good for two years. They are worn by those who have to work in cold or wet places, such as tanneries, breweries, and livery stables, and by workmen in steel mills and glass factories who must walk on hot grates or floors. Farmers, too, are classed among the users.

* * *

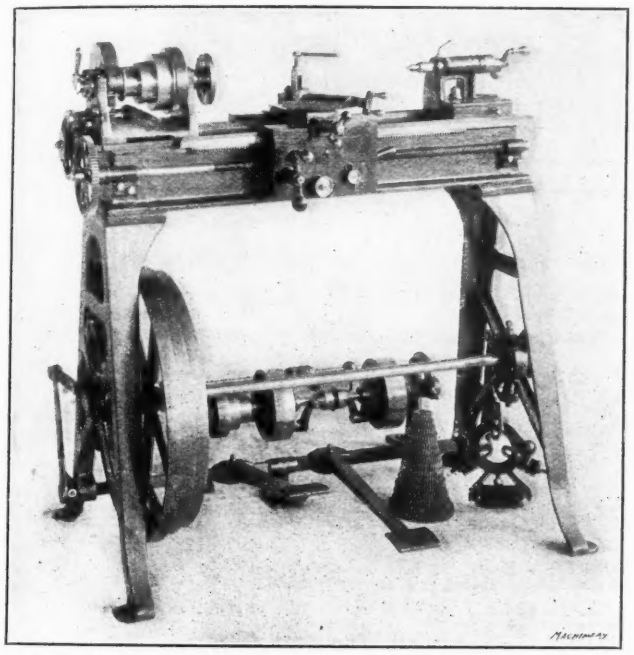
The melting points of some metals which fuse at very high temperatures are published by G. K. Burgess and R. G. Waltenberg in the *Journal of the Washington Academy of Science*. The melting points are as follows: Titanium, 1795 degrees C. (3263 degrees F.); vanadium, 1720 degrees C. (3128 degrees F.); chromium, 1520 degrees C. (2768 degrees F.); manganese, 1260 degrees C. (2300 degrees F.); iron, 1530 degrees C. (2786 degrees F.); cobalt, 1478 degrees C. (2692 degrees F.); nickel, 1452 degrees C. (2545 degrees F.)

A TRADE SCHOOL PRODUCT*

BY JAMES F. JOHNSON†

A commercial product of the State Trade Education Shop of Bridgeport, Conn., is shown in the accompanying illustration. The machine is a 9-inch screw-cutting lathe designed to cut from four to forty threads per inch. It is fitted with steady-rest, follow-rest, and attachments for taper turning, and has a compound rest graduated to 180 degrees. The carriage is fitted with a power cross-feed and a micrometer collar reading to thousandths. In case the countershaft drive is not desired, the lathe is made convertible so that foot power drive may be substituted, as the illustration indicates.

These lathes are constructed for the purpose of giving the apprentice definite training along just such lines as he will encounter when he has completed his trade school work, as he performs a variety of work involving many operations. The fact that it is a commercial product, requires a degree of accuracy that the apprentice would not find in other work. The delivery being promised at a certain date, keeps the boys on the alert, and with a careful system of time keeping and job cards, the apprentice is placed under the same conditions as exist in modern machine shops, while, at the same time, he is receiving definite instruction in his particular trade. To



Nine-inch Screw Cutting Lathe built by Apprentice Boys at State Trade Education Shop, Bridgeport, Conn.

enable him to better understand the work and make him a more thorough mechanic, there is taught in connection with shop work, practical shop mechanics and shop mathematics.

The boy who cuts a lead-screw for a lathe has a mathematical understanding of screw threads, including the Acme thread and the square thread; the depth of the cut for this particular pitch as well as other pitches; the area of the section across the bottom of the screw, as well as problems relating to the time element in cutting the screw. In shop mechanics, the apprentice learns about gear combinations for cutting this particular pitch thread in the lead-screw; how speeds are effected by compounding gear trains; and similar problems.

The boys that cut the gears used on the lathe are taught in their shop mathematics the method of finding the diameter of the gear blanks for this particular pitch gear and for other gears; the required depth of cut for forming a tooth, and calculations concerning other problems in gearing. In mechanics the boys study subjects relating to the strength of gear teeth, speeds of gears, etc.

In the shop drawing class instruction is given in blueprint reading and the making of such drawings as are necessary to enable the boys to understand clearly the relation of the blueprints to shop practice. Instruction is also given in the making of working sketches such as the up-to-date mechanic is often called upon to make.

The lathe illustrated is a complete product of the boys of the trade school, each department contributing its part in making it a commercial success. The design for the lathe and the necessary tools, jigs and fixtures for its completion, were made in the drafting department. The drafting department was thus enabled to do real drafting and now takes much pride in reviewing the results of its work. Real live problems were furnished as, for example, the design of the proper gear train to cut the desired threads, the change necessary to cut the standard metric threads; the design of the headstock, the power cross-feed, together with the compound rest, and the apron mechanism.

The patterns were built by the boys in the patternmaking department, where the same shop conditions prevailed. The apprentice patternmaker worked from the drawings made by the apprentice draftsman and these furnished the necessary instruction for the patternmaking foreman. As we have no cupola, our castings were made outside. This gave our patterns a severe but very successful test. This fact together with the fact that the completed machine was a success, gave the boys considerable self-confidence and a realization of what was before them in the trade.

In the machine shop the apprentices handled the castings made from the patterns built by the apprentice patternmakers and machined them according to the drawings made by the drafting room apprentices. The work in the machine shop was so arranged that each apprentice was carried through a well organized scheme of machine shop practice, the boys securing a good systematic training. They quickly realized the importance of the job and an active and eager interest was always shown. As in all departments, the standard and accuracy of the work accepted was that of the successful machine shop.

After the apprentices assembled the lathes, they were all tested as to running qualities, feeds, thread cutting, and accuracy of turning—this last test showing a variation of 0.0005 inch on a test bar 20 inches long. The boys in the paint shop put on the final touches and the machines were crated by the carpenters and shipped to the customer. The value of this work in instructing the apprentice in his future trade can hardly be overestimated. He is put under shop conditions at work upon a product that is going to be of use to somebody and he is right "up against it," so to speak. He is able to see what will be expected of him later, and he gets an excellent opportunity to learn his trade under real trade atmosphere.

Since its organization, the policy of the school has been to instruct the apprentice in his trade by giving him real trade work, placing him directly under the care of men who are skilled tradesmen in the particular line he is following. In all departments we have been able to do this successfully. These courses in the trade school at Bridgeport are open to any boy between the ages of fourteen and sixteen, or to any boy who has completed the sixth grade at school. He must attend the shops forty-eight hundred hours and perform his work in an acceptable manner. In connection with his trade practice, he devotes about twelve hundred hours to receiving instruction in blueprint reading, practical shop drawings, shop mathematics and practical shop mechanics.

That the depleting ranks of the tradesmen must be filled is a certainty. That our tradesmen need training in their work can no longer be argued. That the American trades need a better class of skilled intelligent workmen is shown in the products of our European friends. If we as a nation are to be supreme in trade pursuits, we must educate our tradesmen and supply the trades with the best class of tradesmen possible. Our trade school is far-reaching. By means of our continuation school, part time school, and evening school, we are able to reach those who would not receive the benefit of the regular day trade course.

From an educational standpoint we are able to give the boy who would otherwise leave school at fourteen to sixteen, and either enter an occupation with no future for him or hang around and become a nuisance to his friends and himself, a chance to make good and amount to something.

* See "Woods Apprentice Industrial School," December, 1913.
† Superintendent State Trade Education Shop, Bridgeport, Conn.

LATTICE BAR SPACING TABLES

BY CHARLES B. GILBERT*

The accompanying tables for finding the pitch of rivet holes for lattice bars will be found useful both in the drafting-room and in the fabrication plant. The tables give spacing for 2 to 21 spaces inclusive, beginning with 6-inch pitch and advancing by eighths to 12-inch pitch.

The use of the tables is simple, of course. For example, what is the over-all distance center to center of 20 rivet holes in a straight line, the pitch being 6⅝ inches? Inasmuch as there are 20 rivets, there are 19 spaces. Referring to the table opposite 19 and underneath 6⅝, we find 10′ 5⅞″, the distance from center to center of the outside rivet holes.

No. of Spaces	Pitch																No. of Spaces
	6″	6⅛″	6¼″	6⅜″	6½″	6⅝″	6¾″	6⅞″	7″	7⅛″	7¼″	7⅜″	7½″	7⅝″	7¾″	7⅞″	
2	1′ 0″	1′ 0⅛″	1′ 0¼″	1′ 0⅜″	1′ 1″	1′ 1⅛″	1′ 1¼″	1′ 1⅜″	1′ 1⅝″	1′ 2″	1′ 2⅛″	1′ 2¼″	1′ 2⅜″	1′ 3″	1′ 3⅛″	1′ 3¼″	1′ 3⅜″	2
3	1′ 6″	1′ 6⅛″	1′ 6¼″	1′ 7⅛″	1′ 7½″	1′ 7⅞″	1′ 8¼″	1′ 8⅝″	1′ 9″	1′ 9⅜″	1′ 9⅝″	1′ 9⅞″	1′ 10⅛″	1′ 10½″	1′ 10⅝″	1′ 11¼″	1′ 11⅝″	3
4	2′ 0″	2′ 0⅛″	2′ 1″	2′ 1⅛″	2′ 2″	2′ 2⅛″	2′ 3″	2′ 3⅛″	2′ 4″	2′ 4⅛″	2′ 5″	2′ 5⅛″	2′ 6″	2′ 6⅛″	2′ 7″	2′ 7⅛″		4
5	2′ 6″	2′ 6⅛″	2′ 7⅛″	2′ 7⅜″	2′ 8⅛″	2′ 9⅛″	2′ 9⅛″	2′ 10⅛″	2′ 11″	2′ 11⅛″	3′ 0⅛″	3′ 0⅛″	3′ 1⅛″	3′ 2⅛″	3′ 2⅛″	3′ 3⅛″		5
6	3′ 0″	3′ 0⅛″	3′ 1⅛″	3′ 2⅛″	3′ 3″	3′ 3⅛″	3′ 4⅛″	3′ 5⅛″	3′ 6″	3′ 6⅛″	3′ 7⅛″	3′ 8⅛″	3′ 9″	3′ 9⅛″	3′ 10⅛″	3′ 11⅛″		6
7	3′ 6″	3′ 6⅛″	3′ 7⅛″	3′ 8⅛″	3′ 9⅛″	3′ 10⅛″	3′ 11⅛″	4′ 0⅛″	4′ 1″	4′ 1⅛″	4′ 2⅛″	4′ 3⅛″	4′ 4⅛″	4′ 5⅛″	4′ 6⅛″	4′ 7⅛″		7
8	4′ 0″	4′ 1″	4′ 2″	4′ 3″	4′ 4″	4′ 5″	4′ 6″	4′ 7″	4′ 8″	4′ 9″	4′ 10″	4′ 11″	5′ 0″	5′ 1″	5′ 2″	5′ 3″		8
9	4′ 6″	4′ 7⅛″	4′ 8¼″	4′ 9⅛″	4′ 10⅛″	4′ 11⅝″	5′ 0⅝″	5′ 1⅝″	5′ 3″	5′ 4⅛″	5′ 5¼″	5′ 6⅝″	5′ 7⅞″	5′ 8⅝″	5′ 9⅝″	5′ 10⅞″		9
10	5′ 0″	5′ 1⅛″	5′ 2⅛″	5′ 3⅛″	5′ 5″	5′ 6⅛″	5′ 7⅛″	5′ 8¼″	5′ 10″	5′ 11⅛″	6′ 0⅛″	6′ 1⅛″	6′ 3″	6′ 4⅛″	6′ 5⅛″	6′ 6⅛″		10
11	5′ 6″	5′ 7⅛″	5′ 8⅛″	5′ 10⅛″	5′ 11⅛″	6′ 0⅞″	6′ 2⅛″	6′ 3⅝″	6′ 5″	6′ 6⅛″	6′ 7⅛″	6′ 9⅛″	6′ 10⅛″	7′ 0″	7′ 1⅛″	7′ 2⅛″		11
12	6′ 0″	6′ 1⅛″	6′ 3″	6′ 4⅛″	6′ 6″	6′ 7⅛″	6′ 9″	6′ 10⅛″	7′ 0″	7′ 1⅛″	7′ 3″	7′ 4⅛″	7′ 6″	7′ 7⅛″	7′ 9″	7′ 10⅛″		12
13	6′ 6″	6′ 7⅛″	6′ 9⅛″	6′ 10⅞″	7′ 0⅛″	7′ 2⅛″	7′ 3⅛″	7′ 5⅛″	7′ 7″	7′ 8⅛″	7′ 10⅛″	7′ 11⅞″	8′ 1⅛″	8′ 3⅛″	8′ 4⅛″	8′ 6⅛″		13
14	7′ 0″	7′ 1⅛″	7′ 3⅛″	7′ 5⅛″	7′ 7″	7′ 8⅛″	7′ 10⅛″	8′ 0⅛″	8′ 2″	8′ 3⅛″	8′ 5⅛″	8′ 7⅛″	8′ 9″	8′ 10⅛″	9′ 0⅛″	9′ 2⅛″		14
15	7′ 6″	7′ 7⅛″	7′ 9¼″	7′ 11⅝″	8′ 1⅛″	8′ 3⅝″	8 5⅛″	8′ 7⅛″	8′ 9″	8′ 10⅞″	9′ 0⅝″	9′ 2⅝″	9′ 4⅛″	9′ 6⅝″	9′ 8⅛″	9′ 10⅛″		15
16	8′ 0″	8′ 2″	8′ 4″	8′ 6″	8′ 8″	8′ 10″	9′ 0″	9′ 2″	9′ 4″	9′ 6″	9′ 8″	9′ 10″	10′ 0″	10′ 2″	10′ 4″	10′ 6″		16
17	8′ 6″	8′ 8⅛″	8′ 10¼″	9′ 0⅛″	9′ 2⅛″	9′ 4⅝″	9′ 6⅝″	9′ 8⅛″	9′ 11″	10′ 1⅝″	10′ 3⅛″	10′ 5⅛″	10′ 7¼″	10′ 9⅛″	10′ 11⅛″	11′ 1⅝″		17
18	9′ 0″	9′ 2⅛″	9′ 4½″	9′ 6⅛″	9′ 9″	9′ 11⅛″	10′ 1⅛″	10′ 3¾″	10′ 6″	10′ 8⅛″	10′ 10½″	11′ 0⅛″	11′ 3″	11′ 5½″	11′ 7¾″	11′ 9⅝″		18
19	9′ 6″	9′ 8⅛″	9′ 10½″	10′ 1⅛″	10′ 3⅛″	10′ 5⅞″	10′ 8⅛″	10′ 10⅛″	11′ 1″	11′ 3⅛″	11′ 5⅛″	11′ 8⅛″	11′ 10½″	12′ 0⅞″	12′ 3¼″	12′ 5⅛″		19
20	10′ 0″	10′ 2⅛″	10′ 5″	10′ 7⅛″	10′ 10″	11′ 0⅛″	11′ 3″	11′ 5½″	11′ 8″	11′ 10½″	12′ 1″	12′ 3½″	12′ 6″	12′ 8½″	12′ 11″	13′ 1⅛″		20
21	10′ 6″	10′ 8⅛″	10′ 11½″	11′ 1⅝″	11′ 4½″	11′ 7⅛″	11′ 9¼″	12′ 0⅛″	12′ 3″	12′ 5⅛″	12′ 8¼″	12′ 10⅝″	13′ 1½″	13′ 4⅛″	13′ 6¾″	13′ 9⅛″		21

Machinery

No. of Spaces	Pitch																No. of Spaces
	8″	8⅛″	8¼″	8⅜″	8½″	8⅝″	8¾″	8⅞″	9″	9⅛″	9¼″	9⅜″	9½″	9⅝″	9¾″	9⅞″	
2	1′ 4″	1′ 4⅛″	1′ 4¼″	1′ 4⅜″	1′ 5″	1′ 5⅛″	1′ 5⅛″	1′ 5⅜″	1′ 6″	1′ 6⅛″	1′ 6⅛″	1′ 6⅜″	1′ 7″	1′ 7⅛″	1′ 7⅛″	1′ 7⅜″	2
3	2′ 0″	2′ 0⅛″	2′ 0¼″	2′ 1⅛″	2′ 1½″	2′ 1⅞″	2′ 2⅛″	2′ 2⅝″	2′ 3″	2′ 3⅜″	2′ 3⅝″	2′ 3¾″	2′ 4⅛″	2′ 4⅛″	2′ 5⅛″	2′ 5⅝″	3
4	2′ 8″	2′ 8⅛″	2′ 9″	2′ 9⅛″	2′ 10″	2′ 10⅛″	2′ 11″	2′ 11½″	3′ 0″	3′ 0½″	3′ 1″	3′ 1½″	3′ 2″	3′ 2½″	3′ 3″	3′ 3½″	4
5	3′ 4″	3′ 4⅛″	3′ 5¼″	3′ 5⅞″	3′ 6½″	3′ 7⅛″	3′ 7⅞″	3′ 8⅝″	3′ 9″	3′ 9⅝″	3′ 10¼″	3′ 10⅞″	3′ 11¼″	4′ 0½″	4′ 0⅞″	4′ 1⅝″	5
6	4′ 0″	4′ 0⅛″	4′ 1½″	4′ 2½″	4′ 3″	4′ 3⅝″	4′ 4¼″	4′ 5¼″	4′ 6″	4′ 6⅝″	4′ 7½″	4′ 8¼″	4′ 9″	4′ 9⅝″	4′ 10½″	4′ 11½″	6
7	4′ 8″	4′ 8⅛″	4′ 9⅝″	4′ 10⅝″	4′ 11½″	5′ 0⅝″	5′ 1½″	5′ 2½″	5′ 3″	5′ 3⅝″	5′ 4¼″	5′ 5⅛″	5′ 6¼″	5′ 7⅛″	5′ 8¼″	5′ 9¼″	7
8	5′ 4″	5′ 5″	5′ 6″	5′ 7″	5′ 8″	5′ 9″	5′ 10″	5′ 11″	6′ 0″	6′ 1″	6′ 2″	6′ 3″	6′ 4″	6′ 5″	6′ 6″	6′ 7″	8
9	6′ 0″	6′ 1⅛″	6′ 2¼″	6′ 3⅜″	6′ 4½″	6′ 5⅝″	6′ 6¾″	6′ 7⅞″	6′ 9″	6′ 10⅛″	6′ 11⅛″	7′ 0⅛″	7′ 1⅛″	7′ 2⅜″	7′ 3⅜″	7′ 4⅝″	9
10	6′ 8″	6′ 9¼″	6′ 10½″	6′ 11⅝″	7′ 0¾″	7′ 2″	7′ 3⅛″	7′ 4¼″	7′ 5⅝″	7′ 6⅞″	7′ 8¼″	7′ 9⅝″	7′ 10⅞″	8′ 0⅛″	8′ 1⅜″	8′ 2½″	10
11	7′ 4″	7′ 5⅝″	7′ 7″	7′ 8⅜″	7′ 9½″	7′ 10⅝″	8′ 0″	8′ 1¼″	8′ 2½″	8′ 3⅝″	8′ 5″	8′ 6⅜″	8′ 7½″	8′ 8⅝″	8′ 9¾″	8′ 11″	11
12	8′ 0″	8′ 1½″	8′ 3″	8′ 4½″	8′ 6″	8′ 7½″	8′ 9″	8′ 10½″	9′ 0″	9′ 1½″	9′ 3″	9′ 4½″	9′ 6″	9′ 7½″	9′ 9″	9′ 10½″	12
13	8′ 8″	8′ 9⅝″	8′ 11¼″	9′ 0⅞″	9′ 2½″	9′ 4⅛″	9′ 5⅝″	9′ 7¼″	9′ 9″	9′ 10⅝″	10′ 0½″	10′ 2⅛″	10′ 3½″	10′ 5⅛″	10′ 6⅝″	10′ 8¼″	13
14	9′ 4″	9′ 5⅞″	9′ 7½″	9′ 9¼″	9′ 11″	10′ 0⅝″	10′ 2⅛″	10′ 4″	10′ 6″	10′ 7⅝″	10′ 9¼″	10′ 10⅞″	11′ 0½″	11′ 2⅛″	11′ 3¾″	11′ 5⅜″	14
15	10′ 0″	10′ 1⅞″	10′ 3⅝″	10′ 5⅜″	10′ 7¼″	10′ 8¾″	10′ 10¼″	11′ 1½″	11′ 3″	11′ 4⅜″	11′ 6″	11′ 7⅝″	11′ 9¼″	11′ 10⅞″	12′ 0½″	12′ 2⅛″	15
16	10′ 8″	10′ 10″	11′ 0″	11′ 2″	11′ 4″	11′ 6″	11′ 8″	11′ 10″	12′ 0″	12′ 2″	12′ 4″	12′ 6″	12′ 8″	12′ 10″	13′ 0″	13′ 2″	16
17	11′ 4″	11′ 6⅛″	11′ 8¼″	11′ 10⅝″	12′ 0½″	12′ 2⅝″	12′ 4⅝″	12′ 6⅞″	12′ 9″	12′ 11⅛″	13′ 1⅞″	13′ 3⅝″	13′ 5½″	13′ 7⅝″	13′ 9⅝″	13′ 11⅞″	17
18	12′ 0″	12′ 2⅛″	12′ 4½″	12′ 6⅝″	12′ 9″	12′ 11¼″	13′ 1½″	13′ 3⅝″	13′ 6″	13′ 8¼″	13′ 10½″	14′ 0⅝″	14′ 3″	14′ 5½″	14′ 7⅝″	14′ 9⅝″	18
19	12′ 8″	12′ 10⅝″	13′ 0⅝″	13′ 3⅛″	13′ 5½″	13′ 7⅞″	13′ 10¼″	14′ 0⅝″	14′ 3″	14′ 5⅝″	14′ 7⅞″	14′ 10½″	15′ 0½″	15′ 2⅞″	15′ 5½″	15′ 7⅝″	19
20	13′ 4″	13′ 6½″	13′ 9″	13′ 11½″	14′ 2″	14′ 4½″	14′ 7″	14′ 9½″	15′ 0″	15′ 2½″	15′ 5″	15′ 7½″	15′ 10″	16′ 0½″	16′ 3″	16′ 5½″	20
21	14′ 0″	14′ 2⅝″	14′ 5¼″	14′ 7⅞″	14′ 10½″	15′ 1⅝″	15′ 3¼″	15′ 6⅝″	15′ 9″	15′ 11⅝″	16′ 2¼″	16′ 4⅞″	16′ 7½″	16′ 10⅛″	17′ 0⅝″	17′ 3⅝″	21

Machinery

No. of Spaces	Pitch																No. of Spaces
	10″	10⅛″	10¼″	10⅜″	10½″	10⅝″	10¾″	10⅞″	11″	11⅛″	11¼″	11⅜″	11½″	11⅝″	11¾″	11⅞″	12″	
2	1′ 8″	1′ 8¼″	1′ 8½″	1′ 8¾″	1′ 9″	1′ 9½″	1′ 9½″	1′ 9⅞″	1′ 10″	1′ 10½″	1′ 10½″	1′ 10⅞″	1′ 11″	1′ 11¼″	1′ 11½″	1′ 11⅝″	2′ 0″	2
3	2′ 6″	2′ 6⅜″	2′ 6¾″	2′ 7⅛″	2′ 7½″	2′ 7⅞″	2′ 8¼″	2′ 8⅝″	2′ 9″	2′ 9⅜″	2′ 9¾″	2′ 10⅛″	2′ 10½″	2′ 10⅝″	2′ 11¼″	2′ 11⅝″	3′ 0″	3
4	3′ 4″	3′ 4⅜″	3′ 5″	3′ 5⅝″	3′ 6″	3′ 6½″	3′ 7″	3′ 7½″	3′ 8″	3′ 8½″	3′ 9″	3′ 9½″	3′ 10″	3′ 10½″	3′ 11″	4′ 0″	4′ 0″	4
5	4′ 2″	4′ 2⅜″	4′ 3″	4′ 3⅞″	4′ 4½″	4′ 5⅛″	4′ 5⅝″	4′ 6⅛″	4′ 7″	4′ 7⅝″	4′ 8¼″	4′ 8⅞″	4′ 9½″	4′ 10⅛″	4′ 10¾″	4′ 11⅝″	5′ 0″	5
6	5′ 0″	5′ 0⅜″	5′ 1½″	5′ 2¼″	5′ 3″	5′ 3⅝″	5′ 4½″	5′ 5¼″	5′ 6″	5′ 6⅝″	5′ 7½″	5′ 8¼″	5′ 9″	5′ 9⅝″	5′ 10½″	5′ 11½″	6′ 0″	6
7	5′ 10″	5′ 10⅞″	5′ 11¾″	6′ 0⅝″	6′ 1½″	6′ 2⅜″	6′ 3¼″	6′ 4⅛″	6′ 5″	6′ 5⅞″	6′ 6¾″	6′ 7⅝″	6′ 8½″	6′ 9⅜″	6′ 10¼″	6′ 11⅛″	7′ 0″	7
8	6′ 8″	6′ 9″	6′ 10″	6′ 11″	7′ 0″	7′ 1″	7′ 2″	7′ 3″	7′ 4″	7′ 5″	7′ 6″	7′ 7″	7′ 8″	7′ 9″	7′ 10″	7′ 11″	8′ 0″	8
9	7′ 6″	7′ 7⅛″	7′ 8¼″	7′ 9⅜″	7′ 10½″	7′ 11⅝″	8′ 0⅝″	8′ 1⅝″	8′ 3″	8′ 4⅛″	8′ 5¼″	8′ 6⅜″	8′ 7½″	8′ 8⅝″	8′ 9½″	8′ 10⅞″	9′ 0″	9
10	8′ 4″	8′ 5¼″	8′ 6¼″	8′ 7⅜″	8′ 9″	8′ 10¼″	8′ 11⅛″	9′ 0⅛″	9′ 2″	9′ 3¼″	9′ 4¼″	9′ 5⅜″	9′ 7″	9′ 8¼″	9′ 9½″	9′ 10⅝″	10′ 0″	10
11	9′ 2″	9′ 3⅜″	9′ 4⅝″	9′ 6⅛″	9′ 7½″	9′ 8⅞″	9′ 10¼″	9′ 11⅝″	10′ 1″	10′ 2⅝″	10′ 3½″	10′ 5⅛″	10′ 6½″	10′ 7⅞″	10′ 9¼″	10′ 10⅝″	11′ 0″	11
12	10′ 0″	10′ 1½″	10′ 3″	10′ 4½″	10′ 6″	10′ 7½″	10′ 9″	10′ 10½″	11′ 0″	11′ 1½″	11′ 3″	11′ 4½″	11′ 6″	11′ 7½″	11′ 9″	11′ 10½″	12′ 0″	12
13	10′ 10″	10′ 11⅝″	11′ 1¼″	11′ 2⅞″	11′ 4⅛″	11′ 6⅛″	11′ 7⅝″	11′ 9⅝″	11′ 11″	12′ 0⅝″	12′ 2¼″	12′ 3⅞″	12′ 5½″	12′ 7⅛″	12′ 8⅝″	12′ 10⅝″	13′ 0″	13
14	11′ 8″	11′ 9⅝″	11′ 11½″	12′ 1⅜″	12′ 3″	12′ 4⅝″	12′ 6½″	12′ 8¼″	12′ 10″	12′ 11⅝″	13′ 1½″	13′ 3¼″	13′ 5″	13′ 6⅝″	13′ 8½″	13′ 10½″	14′ 0″	14
15	12′ 6″	12′ 7⅝″	12′ 9¼″	12′ 11⅝″	13′ 1½″	13′ 3⅝″	13′ 5½″	13′ 7⅛″	13′ 9″	13′ 10⅝″	14′ 0½″	14′ 2⅝″	14′ 4½″	14′ 6⅝″	14′ 8½″	14′ 10½″	15′ 0″	15
16	13′ 4″	13′ 6″	13′ 8″	13′ 10″	14′ 0″	14′ 2″	14′ 4″	14′ 6″	14′ 8″	14′ 10″	15′ 0″	15′ 2″	15′ 4″	15′ 6″	15′ 8″	15′ 10″	16′ 0″	16
17	14′ 2″	14′ 4⅜″	14′ 6¼″	14′ 8⅝″	14′ 10½″	15′ 0⅝″	15′ 2⅝″	15′ 4⅞″	15′ 7″	15′ 9⅛″	15′ 11¼″	16′ 1⅜″	16′ 3½″	16′ 5⅝″	16′ 7¾″	16′ 9⅞″	17′ 0″	17
18	15′ 0″	15′ 2¼″	15′ 4½″	15′ 6⅝″	15′ 9″	15′ 11¼″	16′ 1½″	16′ 3⅝″	16′ 6″	16′ 8¼″	16′ 10½″	17′ 0⅝″	17′ 3″	17′ 5½″	17′ 7½″	17′ 9⅝″	18′ 0″	18
19	15′ 10″	16′ 0⅜″	16′ 2¾″	16′ 5⅛″	16′ 7½″	16′ 9⅞″	17′ 0½″	17′ 2⅝″	17′ 5″	17′ 7⅜″	17′ 9¾″	18′ 0⅛″	18′ 2½″	18′ 4¾″	18′ 7½″	18′ 9⅝″	19′ 0″	19
20	16′ 8″	16′ 10½″	17′ 1″	17′ 3½″	17′ 6″	17′ 8½″	17′ 11″	18′ 1½″	18′ 4″	18′ 6½″	18′ 9″	18′ 11½″	19′ 2″	19′ 4½″	19′ 7″	19′ 9½″	20′ 0″	20
21	17′ 6″	17′ 8¾″	17′ 11¼″	18′ 1⅝″	18′ 4½″	18′ 7⅛″	18′ 9¾″	19′ 0⅝″	19′ 3″	19′ 5⅝″	19′ 8¼″	19′ 10⅞″	20′ 1½″	20′ 4⅛″	20′ 6¾″	20′ 9⅝″	21′ 0″	21

Machinery

* Address: 122 Louden St., Philadelphia, Pa.

MAKING HIGH-EFFICIENCY WORM-GEARING*

METHODS EMPLOYED BY THE CLEVELAND WORM & GEAR CO.

BY DOUGLAS T. HAMILTON†

In an endeavor to secure quiet running and efficient rear axle drives for automobiles, various types of gearing have been employed, bevel and worm gearing being the two types most generally used. Bevel gearing has been used with considerable success, and when properly made and aligned shows a high efficiency with comparative quietness in action. When bevel gears begin to wear, however, backlash is introduced, tending to produce "clatter" and the familiar humming sound emitted from a transmission case. Dis-alignment of the gearing reduces the efficiency and also produces noise. Within the last few years worm-gearing has been receiving considerable attention on the part of automobile manufacturers for the following reasons: it is possible to produce this type of drive, with the proper equipment, more cheaply than the best bevel

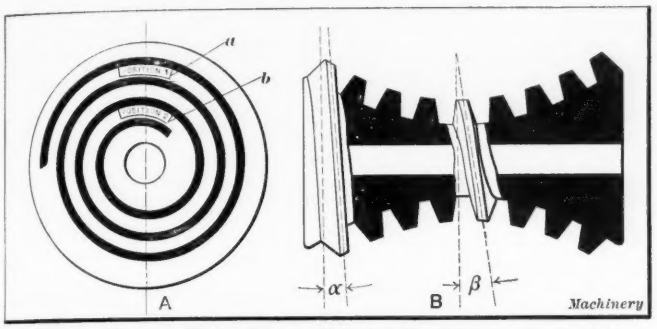


Fig. 1. Diagram illustrating an Objectionable Point in the Contact of the Globoid or Hindley Type of Worm

gearing; it is much more quiet in action; has a longer life; and if properly made, has a higher efficiency and smoother action.

Different Types of Worm-gearing

Generally speaking, there are three distinct types of worm-gearing that have been applied to rear axle drives. The first is the common type of worm drive produced by the ordinary gear hobbing machine method, which generally shows a comparatively low efficiency. The second type is globoid gearing, more commonly called Hindley or hour-glass type of worm-gearing. This shows a very high efficiency, but owing to the refinement necessary in its manufacture and alignment, as will be described later, has not given the satisfactory service that its design would indicate. The third type, and the one on which this article is based, is not so well known as

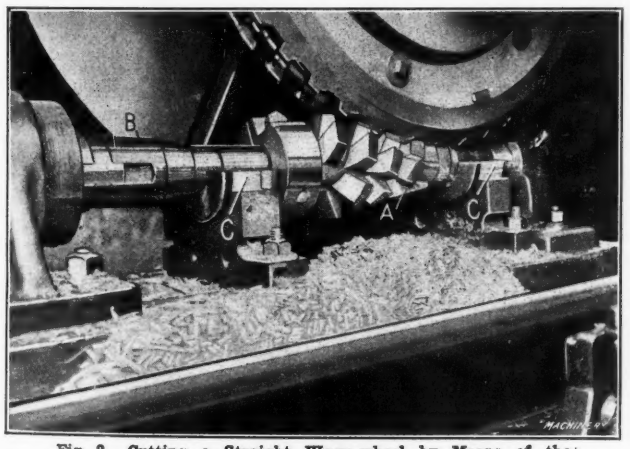


Fig. 2. Cutting a Straight Worm-wheel by Means of the Tapered Hob Method

the other two, but judging from various experiments and tests that have been made gives a high efficiency and long life combined with quiet running and smooth action. It is known as the "straight worm" type of drive, this name serving to differentiate it from the Hindley type in which the

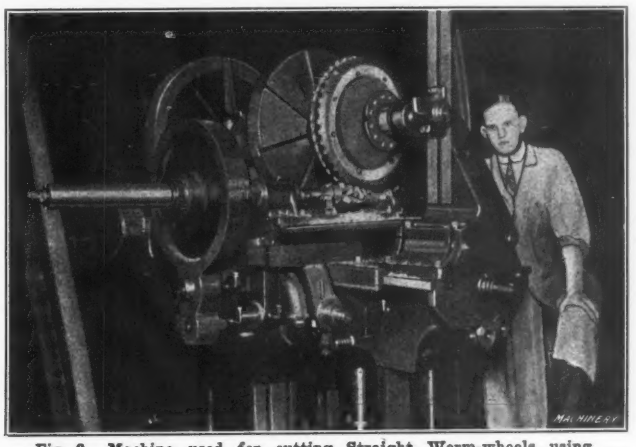


Fig. 3. Machine used for cutting Straight Worm-wheels using Tapered Hobs

worm is curved to conform with the circumference of the worm-wheel.

Globoid or Hindley Worm-gearing

The purpose in designing globoid or Hindley worm-gearing is to enlarge the surfaces in contact so as to reduce wear, and obtain relatively small dimensions—pitch of teeth, etc. While, theoretically speaking, the conditions obtained in this

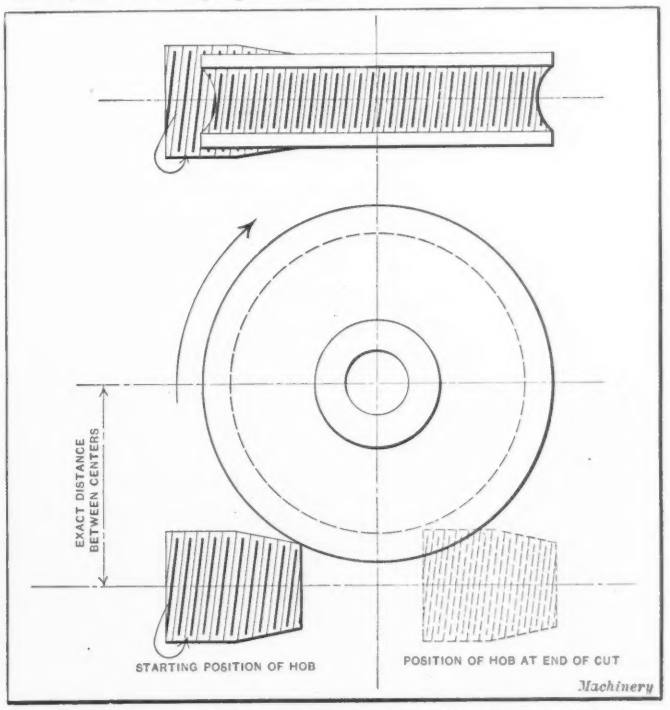


Fig. 4. Diagram illustrating Manner in which Tapered Hob is presented to Worm-wheel Blank

type of gearing would seem almost perfect, there are, in practice, serious objections to its use where dis-alignment of the gearing occurs. To illustrate one weak point in this type of gearing Fig. 1 is presented, in which the ordinary type of scroll used in lathe chucks serves as a means of illustration and comparison. In Position 1 one tooth of the jaw *a* is put into the outer part of the scroll, and in Position 2, the tooth *b* of the jaw is put in the inner part of the scroll. It will be observed that, in theory, the tooth of the jaw has contact only on one vertical line. Now on an ordinary screw the pitch angle depends on the lead and on the pitch diameter, and the angle of inclination of the threads is uniform from end to end. Such is not the case in the Hindley worm where the diameter increases with the length, or in other words, enlarges on each side of a vertical line drawn through the

* For additional information on the making and application of worm-gearing for various purposes, see the following articles previously published in MACHINERY, "Making Hindley Worm-Gearing at the Brooklyn Navy Yard," November, 1912; "Efficiency of Worm-Gearing for Automobile Transmissions," September, 1912; "Worm and Helical Gears as Applied to Rear Axle Drives," September, 1912 (engineering edition); "Cutting Hindley Worm-Gearing on the Schuchardt & Schutte Gear-Hobbing Machine," July, 1911; "Table for Calculating the Outside Diameter of Worm-Wheels," April, 1911; "Worm-Gearing Employed for Freight Elevators," December, 1910; "Allowable Load and Efficiency of Worm-Gearing," September, 1910; and other articles there referred to.

†Associate Editor of MACHINERY.

axis of the worm-wheel and the center of the worm.

At *B* in Fig. 1 it will be seen that the angle β of the screw line in the middle portion of the globoid worm is greater than the angle α at the outside. This means that the conditions of contact are similar to those in the lathe scroll as shown at *A* in Fig. 1. Further, the difference in the theoretical peripheral velocity of the worm would have a tendency to retard the advance of the worm-wheel. From these and other well-known points in gearing, it is evident that the conditions for contact are not so favorable as they are sometimes supposed. In practice, it is not a simple matter in all cases to get the center or hollow of the worm exactly in conformity with the center of the worm-wheel. This, however, is one of the conditions necessary in the alignment of Hindley worm-gearing if good results are to be expected. Hindley worm-gearing shows a very high efficiency when new and when set up in proper alignment, but just as soon as the least wear begins to take place, the efficiency immediately drops. This subject has been admirably treated in an

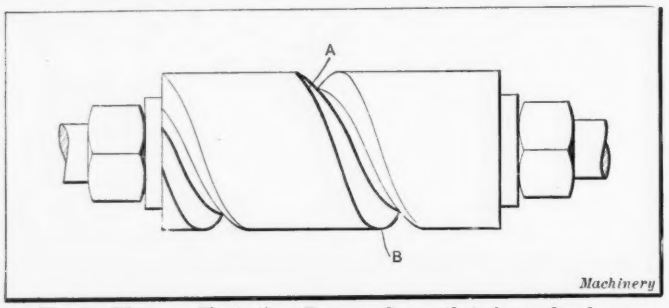


Fig. 5. Diagram illustrating Reverse Curve that is produced on Worm-wheel Teeth by hobbing with a Tapered Hob fed longitudinally and at Right Angles to the Axis of the Worm-wheel Blank

article entitled "The Hindley Worm Gear," by John Edgar, which appeared in the December, 1908, number of MACHINERY, engineering edition.

Straight Worm Type of Worm-gearing

The worm-gearing to be described in the following is known as the "straight worm" type, as previously mentioned. In the straight worm type the difficulties in alignment common to globoid gearing are eliminated, because the center portion of the worm does not have to bear any direct relation to the center of the worm-wheel. The only requirement is that the center distances of the worm and worm-wheel must be exact if perfect action and high efficiency are to result. In the method to be described, this important point is carefully provided for and is comparatively easy of attainment. Fig. 2 shows a close view of the machine used for cutting the straight type of worm-wheel. By this method a taper worm hob *A* held on the arbor *B* is used. The arbor is supported in bearing shoes *C* which are retained in blocks fastened to the table of the machine. The hob is set by means of a

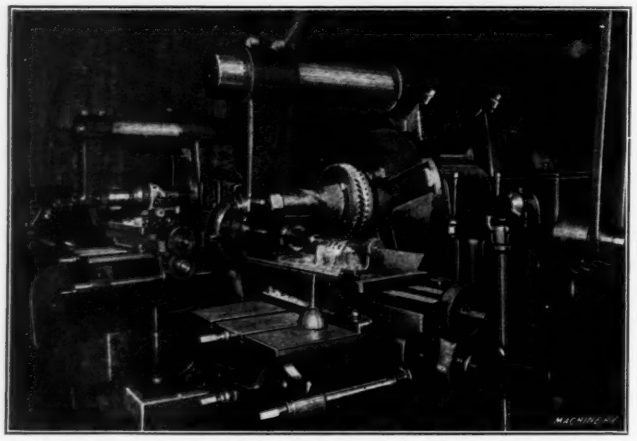


Fig. 6. Two Special Hobbing Machines at work on Worm-wheels for Electric Automobile Rear Axle Drives

vernier and scale at the exact center distance in relation to the worm-wheel blank, and as shown in Fig. 3 is very rigidly supported. The worm hob and work are rotated in the correct relation to each other, and at the same time the hob is fed in a longitudinal direction as indicated in Fig. 4, past the axis of the worm-wheel.

Ordinary and Taper Hob Method of Hobbing Worm-wheels Compared

By applying the hob to the work in the method just described, a theoretically correct and accurate worm-gear is produced, which cannot be excelled where high pitch angles or wide wheel faces—wide in relation to the worm—are concerned. By such a method of production the area of contact between the worm and worm-wheel is as large as possible,

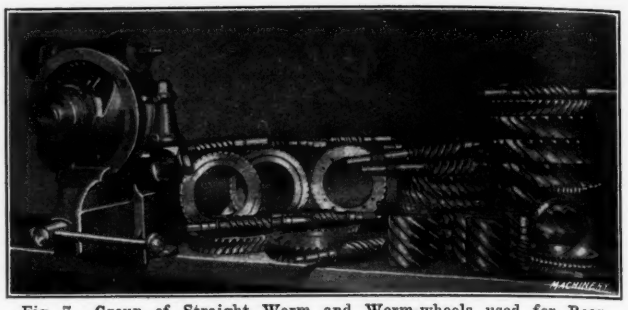


Fig. 7. Group of Straight Worm and Worm-wheels used for Rear Axle Automobile Drives

and provided that a good combination of materials is used, *viz.*, a high grade of phosphor-bronze for the worm-wheel and a good grade of casehardening steel for the worm, this type of gearing shows no appreciable wear under the heaviest loads after having run for a practically unlimited time. In cutting the worm-wheel in this manner, the reversible curve *AB*, Fig. 5, is actually obtained in the worm-wheel tooth. This curve conforms to the path followed by a tooth of the worm in rotating, and in practice is considered to give a surface contact which is impossible to obtain by hobbing worm-wheels in the old way.

The method ordinarily used in hobbing worm-wheels is to gear up the mechanism driving the hob with that actuating

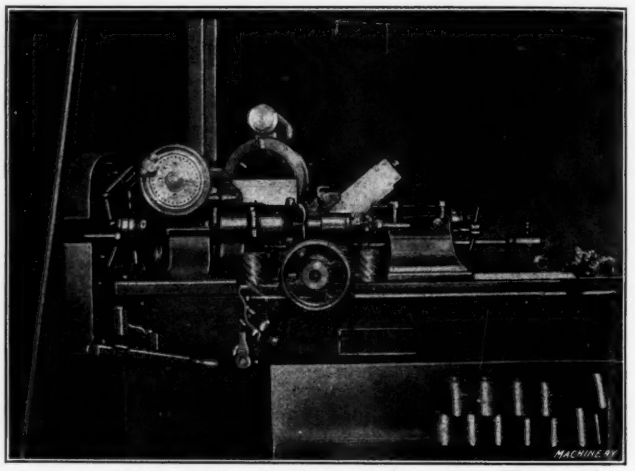


Fig. 8. Thread Milling Machine used for cutting Worms and Tapered Hobs

the dividing wheel which controls the indexing or rotation of the worm-wheel, and to feed the hob axially into the worm-wheel, both hob and blank being rotated at the same time. This action is continued until the hob has been fed in to the correct depth. Now in analyzing this method of cutting the worm-wheel, it will be seen that by presenting the hob in this manner it does not produce a tooth of a theoretically correct shape, for the simple reason that the hob cuts away certain portions of the tooth that are necessary to give a perfect contact with the worm. This is due to the constant changing of the theoretical helix angle of the hob while being fed in axially. Instead, therefore, of producing a worm-wheel tooth that has a reverse curve corresponding with the path through which the face of the worm tooth travels in rotating, this method removes a certain amount of the surface of the worm-wheel tooth that should come in contact with the worm, and in theory the line of contact between a worm-wheel (cut in this manner) and the worm is only on the center. The worm-wheel teeth are relieved toward each end and do not contact at all with the teeth of the worm, these portions of the worm-wheel teeth being removed by the hob in forming them. It will therefore be seen that this method never produces a correct tooth form, and its failings are especially

noticeable as soon as the pitch angle or width of the worm-wheel face becomes somewhat great, resulting in the mutilation of the teeth.

Cutting Straight Worm-wheels

Fig. 3 shows one of the machines employed by the Cleveland Worm & Gear Co., Cleveland, Ohio, for cutting "straight worm-wheels." The hob arbor and the work arbor on this machine both have a positive drive, which is governed by a series of change gears to obtain the required ratio between the worm-wheel and hob. The hob *A*, see Fig. 2, is fed longitudinally and automatically under the blank at the correct speed by means of another series of change gears, located at the left-hand end of the worm-shaft, which drives the work arbor through the dividing wheel. The table of this machine cannot be swiveled one way or the other from a position at right angles to the axis of the work arbor, thus avoiding trouble which has often occurred in the making of worm-gearing by not having the hob cut the worm-wheel at an angle of exactly 90 degrees with the hob axis. When the worm-wheel teeth have not been cut at the correct angle great friction is introduced between the worm and the worm-wheel, especially when the worm is forced to fit in the housing provided for it, which naturally would be machined exactly at an angle of 90 degrees. This machine also has power feeds in all directions and could be used for cutting the Hindley type of worm-gearing if so desired.

In Fig. 6 are shown two smaller type machines at work on worm-wheels for electric pleasure cars, which is one of the

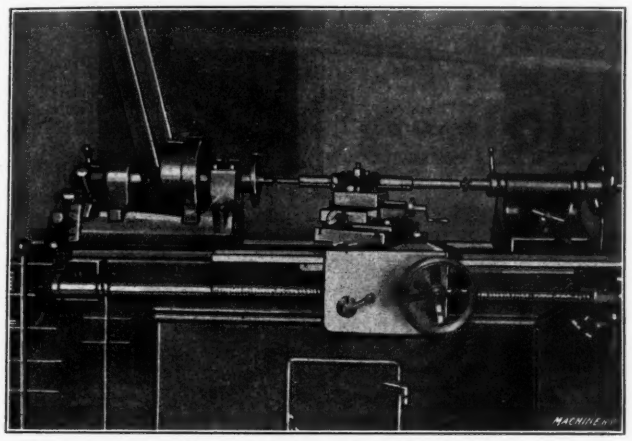


Fig. 9. A Special Type of Lathe used for backing-off or relieving Tapered Hobs

prominent uses being made of this type of worm-wheel. One peculiar feature which is noticeable in cutting a worm-wheel by the tapered hob method illustrated in Fig. 2 is that the hob, in starting to cut on the small end, produces a series of steps on the outside faces of the worm-wheel teeth, and as it feeds in further, the steps are produced on the other side of the teeth. Then as the cutter passes the center all marks are removed, producing a particularly smooth surface and correctly shaped teeth. The two positions of the hob before and after cutting the worm-wheel are indicated in Fig. 4. The hob is fed past the axis of the worm-wheel until the last tooth of the hob passes out of contact with the worm-wheel teeth; this action produces the reverse curve previously referred to. The chief advantages claimed for this worm-wheel is that it has a perfect surface bearing (this, theoretically, would be only a line bearing, but with the aid of the oil film becomes in practice a surface bearing) with the worm teeth for its entire arc of contact. It is also cut theoretically correct, which cannot be said of the ordinary method of worm-wheel hobbing.

A very high degree of accuracy can be obtained by this method of hobbing worm-wheels, owing to the fact that the full size of the hob does not come into play until the finishing cut is reached, so that the teeth of the hob tend to preserve their shape indefinitely. Another point, previously mentioned, that tends to produce accuracy is the fact that the distance between the work arbor and the hob spindle is at all times fixed at exactly the distance between the axis of the worm-wheel and the worm in the finished gearing. This is a refinement of greater importance than is usually realized, and one that is not always looked out for in hobbing operations in which the cutter spindle is fed in toward the work.

Efficiency of Straight Worm-gearing

In order to prove that worm-wheels cut by this method would work out as satisfactorily in practice as theoretical considerations indicated, a number of tests were made by a prominent concern manufacturing pleasure electric cars. In these tests it was found that the efficiency was very high, averaging from 90 to 98 per cent. Continual running ap-

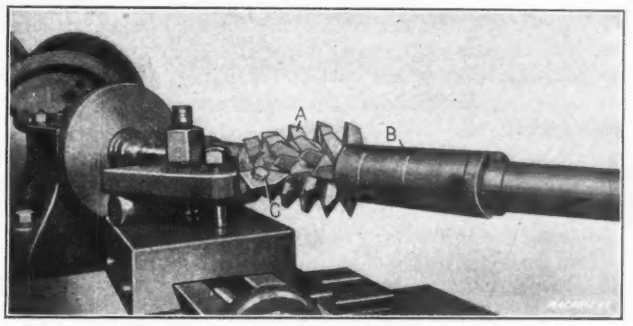


Fig. 10. Close View of Machine shown in Fig. 9 illustrating Method of applying Cutting Tool to Tapered Hob

peared to have but very little effect on the efficiency, and the wear was almost negligible. The way in which the worm and worm-wheels are mounted before being placed in the testing machine is indicated in Fig. 7, where a completed rear axle unit is shown held in an ordinary bench vise. Both worm and worm-wheel shafts run in ball bearings and are held in place so that the center distances of the worm and worm-wheel cannot change due to wear; the only effect that wear has on this type of gearing is to increase the backlash between the worm and worm-wheel teeth. It was also found in these tests that, as far as noise was concerned, the ball bearings did not run anywhere nearly as quietly as the worm and worm-wheel did, which would indicate that from this point of view the conditions met with in this type of gearing are almost ideal. This type of worm-gearing has also proved highly satisfactory for reduction gearing in connection with electric motors. A particularly good example which illustrates the adaptability of this type of gearing to large reductions was a reduction gear having a ratio of 903 to 2 that showed an efficiency of 80 per cent when transmitting 10 horsepower under tests covering a considerable period of time.

Cutting a Straight Worm

The Cleveland Worm & Gear Co. uses a thread milling machine of the type shown in Fig. 8 for cutting straight worms. By means of this machine worm milling becomes quite a sim-

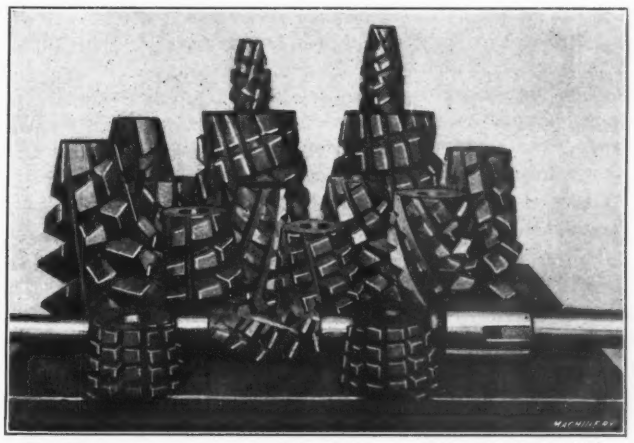


Fig. 11. Group of Tapered Hobs—One necessary for Every Pitch, Pitch Diameter and Variation in Number of Starts on Worm

ple matter, and the machines are so simple in operation that intelligent workmen can easily handle them and turn out good work cheaply and satisfactorily. The cutter head is accurately graduated and can be swiveled either way to the correct angle of the thread. The headstock spindle is hollow, allowing work to pass completely through it, and the cross-slide is provided with an automatic stop. The machine is also stopped automatically, at the end of a thread, thus insuring regularity of length when cutting multiple pitch

worms. There is, of course, as is evident in all milled spiral flutes, a tendency to leave the face of the worm thread cut somewhat concave. In order, therefore, to produce the best results, this company finds it advisable to rough out the worm on the thread milling machine illustrated, and leave a grinding allowance of 0.010 inch on each face of the thread. The worm, after hardening, is then ground by a special machine which corrects this concavity of the worm tooth and also removes any distortion which is likely to occur in hardening.

Making Tapered Hobs

The tapered hobs used for cutting the straight type of worm-wheels are roughed out in the thread milling machine shown in Fig. 8, and are then fluted in the milling machine; before hardening they are backed off in the special backing-off or relieving lathe shown in Fig. 9. This is a patented machine which has been constructed for making gear-cutters of every description as well as side relieved cutters with straight or spiral grooves, right- or left-handed; and if necessary it could be used as an ordinary engine lathe. The longitudinal feed of the carriage is actuated through change gears shown to the left of the machine, and a lead-screw in connection with the usual split nut.

The relieving mechanism works in either direction and can be easily reversed or released; it is actuated by means of a shaft running longitudinally inside of the bed of the machine and by gearing at the right-hand end of the machine. By means of easily interchangeable cams the clearance angles for each special tooth are obtained. The hob *A* to be relieved is held on a special arbor *B*, see Fig. 10, which in actual operation (it is not properly set up in the illustration) is held in the headstock spindle by a screw, and on the other end is supported in a taper bushing held in the tailstock spindle. By means of this method of retaining the arbor, deviation of the work during the relieving operation is impossible as the arbor withstands all pressure from the backing-off tooth *C*. By means of a system of change gears actuated by a lead-screw, a worm-drive and a differential gear, relieving can be obtained to any given length of left- or right-hand spiral. By this arrangement it is also possible to relieve, in addition to the ordinary plain and machine relieved cutters, taps and hobs with any given lead or number of spiral grooves. Provision for relieving spirally fluted hobs is secured by means of the change gears at the right-hand end of the machine. The spacing, of course, is accomplished with cams held on the screw running longitudinally inside of the machine bed. The hob thus relieved is accurate as to shape of tooth, and it is then hardened. In the event of any distortion from hardening, the hob is ground in the special worm-grinding machine previously mentioned.

Fig. 11 shows a group of tapered hobs of various pitches and sizes. For cutting straight worm gearing it is necessary to make a hob for every different pitch, pitch diameter and number of starts on the worm. In making a separate worm hob for each pitch and pitch diameter, the theoretically correctly shaped tooth on the worm-wheel is obtained. The reverse curve previously mentioned is also secured and the action of the worm-wheel teeth with the worm closely approximates ideal conditions. While the making of a hob for each pitch, pitch diameter and number of starts on the worm incurs considerable expense, it is evident that if a perfect working worm and worm-wheel is desired, the expense incident to the making of the hob is of minor consideration.

* * *

The Lackawanna R. R. has recently made tests to determine the practicability of communicating with moving trains by wireless telegraphy. The experiments thus far conducted indicate great possibilities. The Lackawanna has wireless stations at Scranton, Pa., and Binghamton, N. Y. The distance between these two stations is sixty-five miles, and it was found possible to maintain communication with a train running at the rate of fifty-five miles per hour, from one station to the other. The train was equipped with four quadrangular aerials mounted on the roofs of four adjacent cars. The heights of these aerials was limited to eighteen inches to avoid interference with tunnels and bridges. The regular Marconi system is employed except that power is supplied by a special motor-generator set driven from the train lighting dynamo. In the test referred to, when the train had proceeded to a point too far away for the low aerials on the cars to force signals back to the first station direct, the signals were delivered to the station ahead and relayed back to the starting point. At no time during the tests was the train out of communication with both stations.

* * *

FIRST INTERNATIONAL EXPOSITION OF SAFETY AND SANITATION

The First International Exposition of Safety and Sanitation was held in the Grand Central Palace, New York City, December 11-20. Among the large American industries exhibiting the advance that has been made in accident prevention and life-saving methods, appliances and devices were the Pennsylvania, New York Central, Southern Pacific, Baltimore & Ohio and Chicago & North Western railroads, the New York Edison Co., the New York Telephone Co., the National Cash Register Co., the Welin Marine Equipment Co., and the United States Steel Corporation.

The Pennsylvania R. R., which was awarded a gold medal by the American Museum of Safety last year for advance in safety, and which has a remarkable safety organization consisting of thirty safety committees, presided over by a central safety committee, had arranged an interesting exhibit based on practical experience. Men from the various shops demonstrated how they revive a comrade who has been shocked by coming in contact with a third rail.

The New York Central R. R. reproduced at the exposition the safety car which travels over all of the New York Central lines and in which lectures and practical demonstrations in safety work are given. This missionary car for safety was a feature of the exhibit. Other railroads showed progress in safety signaling systems, methods of inspection and rules regarding yard practice for employes.

The New York Edison Co. exhibited the many safety devices in use at the Waterside power stations, where half a million horsepower in electrical energy is generated, and in the various sub-stations throughout New York City. By means of these safety devices the Edison Co. has practically eliminated danger in the careful handling of electricity.

The Welin Marine Equipment Co. showed the progress made in saving life at sea. Their exhibit included davits, rafts, life boats and various kinds of life preservers. The New York Telephone Co., which maintains rest rooms, lunch rooms, and roof gardens for its operators, and which is particularly active in caring for the health and comfort of its thousands of employes, had an interesting exhibit. The United States Steel Corporation showed in a graphic manner how the workers in a hazardous industry are being protected.

In connection with the field hospital exhibited by the United States Army, a detail of fifty soldiers was sent to the exposition from Fort Totten on certain days, and these men went through physical drills and exercises which are especially designed a correct certain physical faults and ailments.

Among the exhibitors of safety devices designed for protecting workers in shops and factories were the following:

Allen Mfg. Co., Hartford, Conn. Safety set-screws.

Bass Bros., 82 Walker St., New York City. Safety guards for woodworking machinery.

Benjamin Electric Mfg. Co., 114 Liberty St., New York. Safety guard for punch presses.

Brown & Sharpe Mfg. Co., Providence, R. I. Charts and photographs of safety appliances.

Corbin Cabinet Lock Co., New Britain, Conn. Safety guard for punch presses.

Max H. Fischer, 41 Park Row, New York City. Hollow set-screws. Safety guards for presses.

L. F. Grammes & Sons, Allentown, Pa. Safety guards for woodworking machinery.

Julius King Optical Co., 12 Maiden Lane, New York City. Safety glasses for protecting the eyes of workmen.

Neverslip Safety Clamp Co., 141 Broadway, New York City. "Neverslip" clamps for handling boiler plates.

Norton Co., Worcester, Mass. Safety and sanitary appliances used in connection with grinding wheels.

T. A. Wilson & Co., Inc., Reading, Pa. Eye protectors for foundry, iron and steel workmen, etc.

Zeh & Hahnemann, Newark, N. J. Safety trip for punch presses.

H. & A. Lock Co., Brooklyn, N. Y. Safety guard for power presses.

PROGRESS OF THE SAFETY MOVEMENT*

A REVIEW OF WORK DONE TO PREVENT ACCIDENTS AND TO PROMOTE HEALTH IN THE INDUSTRIES

BY MANCIUS S. HUTTON†

It has been estimated by conservative competent experts that 35,000 workmen are killed and 2,000,000 injured, and that there are 3,000,000 cases of sickness due to occupational diseases among the industrial workers in this country each year. It is known that between 50 and 60 per cent of this economic and social waste is preventable by proper means. It is in those states which have passed workmen's compensation laws that there is the greatest progress in the promotion of safety and sanitation. At the end of the year 1913 the following twenty-two states have passed such laws:

Arizona;	Michigan;	Oregon;
California;	Minnesota;	Rhode Island;
Connecticut;	Nebraska;	Texas;
Illinois;	Nevada;	West Virginia;
Iowa;	New Hampshire;	Washington;
Kansas;	New Jersey;	Wisconsin.
Maryland;	New York;	
Massachusetts;	Ohio;	

The laws in these different states are not alike, some being more drastic than others. Some apply to all workers, others apply only to those working in hazardous enterprises which are specified. All these state laws are elective, as explained later, with the exception of Arizona, California and Ohio, which are compulsory. In the elective states the employer has the choice of voluntarily accepting the provisions of the act or of working under the common law; in the compulsory states he has no such choice. In order to make the law attractive to the employer, all the states which have already passed workmen's compensation laws and some that have not done so as yet, have changed or stricken from the statute books the old common liability law defenses called the "fellow servant" rule and the "assumption of risk" doctrine. By the fellow servant rule is meant "that the injury was caused by the negligence of another employe engaged in the same employment" and by the assumption of risk doctrine is meant "that the employe assumed the hazard of the occupation." In the past the employer has, in 75 per cent of the cases, by using either or both of these defenses, defeated any suit which the injured employe might institute in court to recover damages due to an injury. In addition, the amount of compensation for any injury has been definitely specified. In Maryland, Massachusetts, Ohio, Oregon, Texas, West Virginia and Washington, the employer is required to insure his men against casualty with a state insurance board or in one of the insurance companies which the state allows to receive such insurance. The employer pays the premiums. In ten states "Industrial Accident Boards" or commissions have been created to administer these laws.

The United States government has already passed laws which compensate for injuries and death for about a quarter of its 400,000 civilian employes. There will be presented to congress during this session a compensation bill which will take care of all these civilians. This bill, which will be introduced by Senator Kern of Indiana, provides for compensation for sickness or death due to occupational diseases as well as accidents. During 1914 there will probably be one state, at least, which will pass a compensation law, and two other states which will change their present laws. Besides providing for adequate and prompt compensation for accidents to industrial workers without the necessity of going to court, fifteen states have taken steps to study the question of occupational sickness among wage workers in the different trades, by requiring physicians to report to a state board or department cases of certain occupational diseases which they may be treating. In the near future these and other states will incorporate occupational diseases as well as accidents in their compensation laws. It has been found on investigation that lead-poisoning lurks in 150 different trades.

In the twenty-two states previously mentioned, laws have been passed which have increased and bettered the state inspection department, given the inspectors more power, increased the punishment imposed for violations of the laws besides requiring certain definite protection to be given to the workers in several of the trades. Where the state has an accident board or commission, the law-makers have delegated the prevention end to such board or commission by means of executive orders instead of enacting individual laws.

Active work in the prevention of mine accidents has advanced since the formation of the Bureau of Mines of the Department of the Interior in 1910. There are about three thousand miners killed every year, of which only fifteen per cent are killed in the large mine disasters which get into the daily papers. About seventy-five per cent of the miners in this country are ignorant foreigners. The investigations which the bureau has carried on during the last four years, have been helpful both to the owners and miners. These investigations have been published by the government and can be obtained free upon request. The bureau has taught miners and mine officials how to carry on rescue work in gaseous mines, how to fight mine fires, and how to give first-aid to injured workers. The government has in operation, at the present time, six mine-safety stations and seven mine-safety railway cars, both fully equipped as regards breathing apparatus, fire-fighting apparatus and materials for first-aid to the injured. These are presided over by a mining engineer who has under him a corps of highly trained miners. Up to the present 7734 miners have been instructed in the carrying on of rescue work with the use of breathing apparatus, in the fighting of mine fires, and the giving of first-aid. Safety lectures have been delivered to 71,500 persons by employes of the bureau. Once a year rescue and first-aid teams from various mines compete for different prizes which are offered by several of the mine companies.

For the last twenty-four years the Interstate Commerce Commission has been collecting statistics of accidents from the railroads doing interstate business. These statistics show that during that period 188,037 persons have been killed and 1,395,618 injured. These persons can be divided into three classes: First, the employes of the railroads; second, passengers; third, "other persons," including trespassers on the tracks. The "other persons" are by far the most numerous being about 62 per cent of the whole number of those killed. Of this 62 per cent, about 85 per cent can be classified as trespassers. The reports of the commission show that a large majority of these trespassers were killed and injured at other points on the track than at the highway crossings. The eliminating of grade crossings, the stationing of gate and flag-men at the crossings, has and will in the future, lessen the number of accidents at these points. One of the greatest problems which the railroads and commissions will have to face will be the question of reducing these trespasser accidents. It is the collisions and derailments in which passengers are killed or injured which get into the front pages of the newspapers but it is a fact that the number of injuries and deaths of passengers is small compared to the number of passengers carried. This is said guardedly since there is still fresh in the memory of almost everyone the terrible disasters which have occurred on one of the eastern roads this last year.

The employes of a railroad can be divided into three classes: First, those who work in the shops and roundhouses; second, those who work in connection with the operation of trains, such as yard and switchmen; third, those who operate the trains, which include the engineer, conductor, firemen and brakeman. The men in the first class are like those in any industrial factory and can be protected some-

* For articles on safety activities previously published in MACHINERY, see "American Museum of Safety Award," February, 1913, and "Museums of Safety and Their Activities," September, 1912, and articles there referred to.

† Address: 257 West 86th St., New York City.

what by means of safety devices and can be helped by working in well lighted, well ventilated buildings, which are not overcrowded so that the aisles and passage-ways can be kept clear. There are not many known safeguards which can be used for the second and third classes of employes. These men must run no risks, be quick of action, have a clear vision and brain, and be sure that they are safe before doing anything. In 1910 there was started a "safety-first" movement among the railroads. At the end of this year there will be sixty-seven railroads having a total mileage of over 183,596, which have organized this movement among their employes. Not a week passes but other railroads are taking up this movement, until within a few years, all the railroads will have joined it. This is nothing more than a practical movement to interest and cooperate with the railroad employes so that they will always think and act "safety first." This is accomplished by various means, among which are workmen's safety committees, talks by railroad officials, illustrated lectures on safety and other methods. The men have appreciated what the companies are doing for them, and they are trying to live up to what is required of them, thereby "boosting safety." The railroads which are active in this movement have been able to show a surprisingly large reduction in the number of accidents. Some of these roads have fitted up cars with traveling exhibits of safeguards. They also carry lantern slides of safety devices and methods of protection. Each car is in charge of one of the road's safety engineers, who goes with the car to the different shops, roundhouses and yard terminals of the road, where he lectures to the men and shows them models of the different safety devices which the company uses.

The statistics given in the foregoing only refer to railroads doing interstate business. The street and interurban railroads, besides the intrastate steam railroads, come under the jurisdiction of the state public service or railroad commission, if such has been created by the legislature of the state. The greatest number of accidents which occur on the street railroads are in the getting on and off of moving cars. The prevention of this class of accidents is in the education of the passengers not to be in a hurry, but to wait till the car stops before proceeding to get on or off. The running or stepping in front of moving cars is always a source of great danger. A large number of these latter accidents happen to thoughtless school children. It might be mentioned that the accidents which have happened since the advent of the motor vehicle and motor truck have been increasing instead of decreasing. State and local ordinances have attempted to decrease speeding and reckless driving by chauffeurs. While these are not industrial accidents, everyone is vitally interested in preventing them as far as possible.

Ever since the *Titanic* disaster of April 15, 1912, when 1517 persons were lost at sea, the United States government and the ship-owners have been trying to prevent a repetition of this calamity. As a result, ships which ply on the navigable rivers and lakes and those leaving ports of this country for foreign destinations, which carry more than 50 persons (crew and passengers), must be equipped with a wireless system having a day or night radius of 100 miles at least. This equipment must be so arranged that it can be independent of the engine room supply of electricity. They are also required to have at least two operators so that one will be on duty all the time. The ships must have enough life boats and rafts to accommodate all the passengers and crew. The life boats, rafts and life preservers are regularly inspected to see that they are in sea-worthy condition. Lifeboat and fire-drills by the crew are supposed to take place at regular intervals. Traveling by water to-day is far safer than it was four or five years ago. While it is a fact that some of the worst marine disasters have happened by collisions or by having the vessel tossed against a shore and knocked to pieces by the wind and waves, yet it is also true that the burnings of ships at sea, or in port, have been more numerous. The burning of the S. S. *Volturno* in the summer of 1913 is only one instance in a long line of such disasters. Even with all the latest apparatus for detecting and extinguishing fires, it sometimes happens that the fire gets beyond control. One of the greatest safeguards of the age, as regards protection at sea, has been the use of wireless telegraph in calling for help from other vessels. In December 1913 there was held in London, England, an "International Conference on Safety at Sea," having representatives from twelve different nations. This conference will make a report as regards its findings.

In 1911 the fire in the Triangle Shirt Waist Co.'s loft occurred in New York, and another disastrous fire in Newark, N. J. The next year there was another large fire in a loft building in Binghamton, N. Y. In each of these fires there was a terrible loss of life among the young women workers in the shops. As the result of investigations conducted after these fires, several of the states have changed existing laws and have enacted others to protect the workers in factories and lofts from such disastrous fires. It would take too long to tell what has been done in the line of fire prevention, but mention will be made of the increased number of, and larger fire escapes built of firmer materials, of fire drills conducted in different shops, of more adequate fire fighting apparatus to extinguish a blaze in its incipiency, of buildings constructed of fire-resisting materials and of other methods by which the fire insurance companies and the owners of factories are improving conditions.

All the work of the government commissions, bureaus, state boards, employers and other officials in accident prevention, hygiene, and sanitation, would count for very little if it did not have the active cooperation of the workers themselves. There are several reasons why the safety movement has taken such big steps within the last year or two. One of these has been the awakening of the employers to the fact that they are their "brothers' keepers" and therefore it is their moral and rightful duty to take every means in their power to keep their workers in health and as free as possible from accident. Second, the employe realizes now that it is his duty to become a partner with his employer in carrying out any safety suggestions that will be helpful to both of them. Again both the employer and his workmen know that they owe it to society at large to decrease the number of accidents and cases of sickness.

Among the agencies which are helping the progress of the safety movement are the museums of safety, one of which is now located in New York at 29 West 39th St. Another will be started with the beginning of this year, in San Francisco, Cal., and still a third will be located in Chicago, Ill., in the near future. Other museums are being considered by several of the state boards and by the national government. These museums are stationary and can be seen only by those who are within a traveling distance of these cities or who may be sojourning in them. The lecture work which members of these museums can give need not be confined to these cities. In fact, during the last three years illustrated lectures have been delivered by officials of the American Museum of Safety before audiences of superintendents, foremen and workers of several large industrial plants and railroads. They have also given the same lectures before meetings of chambers of commerce, factory inspectors, organizations of employers, and others of a similar nature. This last year, safety talks have been given by the New York museum to 449,120 children of the schools of Greater New York.

Some of the railroads and large industrial concerns have printed safety talks which they have sent to the school authorities in the cities in which they are located, for distribution among the school children. Lecture work has been given by officials of the National Association of Manufacturers at the different industrial centers during the last few years. This association is proposing to widen its scope of lectures this coming year by fitting up a train which will carry the lecture officials. One car of this train will be arranged so that it can become a moving picture theater, and another car will carry models and samples of various safety devices. One of the railroads already has a train of this nature for its own use and others are considering doing the same thing. Several of the state boards are doing lecture work among the manufacturers of their states. This edu-

cational lecture work has been a great help to all concerned and one of the leading factors that has brought the safety movement to its present state of development.

Another agency which is helping the movement is the co-operation of the technical journals in the publishing of editorials and articles by leaders of the movement, on questions relating to safety, sanitation and hygiene. The *Railroad Record* publishes once a month an issue devoted wholly to safety and safety engineering, and has each month a section given over to questions regarding safety. Several of the insurance companies which carry liability insurance have been actively promoting the safety movement among their insured. It is not unnatural that new organizations whose members consist of those whose interest centers about this movement, should come into existence as the work progresses. Among such organizations might be mentioned the American Mine Safety Association, and the American Railway Safety Association. In Milwaukee, Wis., from September 30 to October 5, 1913, there was held the "First Cooperative Safety Congress" under the auspices of the association of the Iron and Steel Electrical Engineers. At the end of this congress there was formed a National Council of Industrial Safety to serve as a committee for organizing future congresses. In New York there was held, from December 11 to 20, 1913, the "First International Exhibition of Safety and Sanitation" under the auspices of the American Museum of Safety.

It has not been possible in as short an article as this, to give more than a general outline of the progress in the safety movement since its beginning. No mention has been made of other lines of progress in labor which have helped this movement nor has mention been made of what has been done by the legislatures and the employers in hygiene and sanitation. The safety movement has now become a permanent one in this country and it will progress faster here than it did abroad, since America has their experience to draw from.

* * *

THE "PAPERED" PRESSES

A story is told of a manufacturer who bought some small presses from a concern that built machinery spasmodically—that is, when it had orders to fill. The presses were delivered, and after a time they were taken down for readjustment. The fitting was found to be hardly satisfactory even to a good-natured man. This man was good natured, but being slightly given to sarcasm, he penned the following letter:

John Blank, Esq.:

I have taken down the presses you sold me and am now ready to put them together. Will you please send me some copies of the *Billtown Bugle?* I don't find any paper around here of the same thickness. Shall need three copies to go around.

Yours truly,

Samuel Dash

TEST GAGES FOR AUTOMOBILE CYLINDERS

BY E. H. PRATT*

In the production of automobile cylinders there is always considerable discussion regarding the cylinder bore being square with the flange, and various devices and gages have been designed to test the squareness, which depends upon several conditions: First, the cylinder boring machine must be of very rigid construction; send, the jig for holding the cylinder must be strong and accurate; third, the boring tools must be kept sharp and have the proper clearance; fourth, the cores that form the cylinder barrels must be set true. The cores are the principal cause of the trouble and it seems almost impossible for the foundry to overcome the difficulty. When the cored hole is considerably out of true, the cutters will have more stock to remove from one side of the hole than the other, and, if the spindle of the boring mill is not perfectly adjusted, there will be a certain amount of play or spring that will allow the cutter to follow the core. The error arising from this cause is likely to be in any direction, and, after the finishing cut is taken, it is necessary to test the bore to determine how much it is out of square.

The test gages shown in the accompanying illustrations represent the ideas of various engineers and inspectors. Some

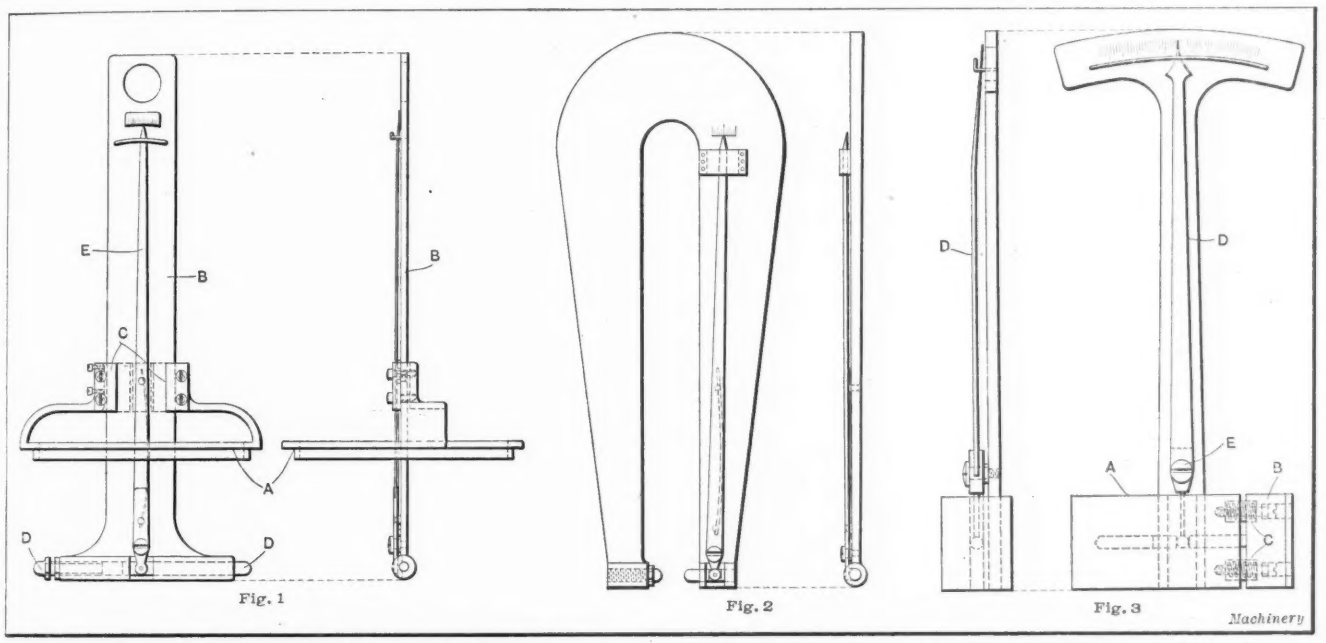


Fig. 1. Gage for testing Squareness between Cylinder Flange and Bore. Fig. 2. Gage for testing Parallelism of Wall between Adjacent Bores. Fig. 3. Gage which shows whether Bore is Cylindrical or Tapering

of them have proved to be very accurate but not economical, owing to their excessive first cost, whereas others are accurate, cost little, and therefore are practical. The gage illustrated in Fig. 1 has previously been shown in MACHINERY'S columns, but is reproduced to make the set complete. The flange *A* of this gage is placed on the cylinder flange, and the bar *B* which slides in bearings *C* is then moved vertically, thus causing the "anvil points" *D* to pass down the sides of the cylinder wall. Any variation is indicated by the relation of pointer *E* to the graduation marks seen at the upper end of the gage. This gage was very successful, but can only be used on one size cylinder, which is a decided disadvantage in a job-shop where cylinders of several diameters are being made.

The gage shown in Fig. 2 is used to test the variation in thickness between the cylinder bores. It was not very successful, inasmuch as both bores could be out of square with the flange while the thickness between them was uniform. The construction of this gage is clearly shown by the illustration. A gage which proved very satisfactory for testing bores for taper is shown in Fig. 3. Attached to one end of the body *A* there is a movable block *B* normally held out by springs *C*. The indicator arm *D* is pivoted at *E* and is connected with the movable block as shown. The frame is graduated on the upper end and is also formed for a handle with which to operate the gage.

* Address: 12 Eagle St., Springfield, Mass.

The gage shown in Fig. 4 is very elaborate and is an extensive improvement over the type shown in Fig. 1. It was designed for use on cylinders varying from 4 to 5 inches in diameter, and gave fairly accurate results, but its use under ordinary circumstances would be prohibitive owing to high cost and complicated construction. The body *A* is made in two pieces to allow machining a dovetailed bearing for the gage slide; the latter has a gib for adjustment and a knurled knob at the top (see plan view) by which the slide is operated vertically. When anvil *C* is in contact with the cylinder wall, any variation in the squareness or size of the bore is shown by pointer *D*, which, through the lever *E*, multiplies the variation twenty-five times. The set-screws *G* are used to adjust the gage for different cylinder diameters. The spring *F* keeps anvil *C* in contact with the cylinder bore. The gage is located on the cylinder by means of two stationary pins *H* and the adjustable pin *J*, which is fastened to rod *K*. The latter is controlled by a spring lever *L* as shown in the plan view. To insure the gage being square with the cylinder flange, pins *M* and knife-edge plate *N* are so located that they will give sufficient bearing on the cylinder, but dirt and chips are not likely to get under the gage and throw it out of alignment, because of the small bearing surfaces.

The gage illustrated in Fig. 5 is simple and effective for a given size cylinder. The cylindrical cast-iron body *A* (see also plan view) is made to fit the cylinder bore and is attached to a seamless tube *B* which acts as a pilot for the knife-gage *C*.

The body *A* is placed into the cylinder bore with pilot *B* extending upward, and square *C* is moved down until it comes in contact with the cylinder flange; tissue paper or steel "feelers" are then used to determine the error between the bore and flange. Square *C* is provided with clamp-screws to take up the wear on tube *B*.

The final result of much experimenting is represented by the gage shown in Fig. 6. This gage can be used in various size cylinders, without changes or adjustments, and is simple, cheap and accurate. There are only four principal parts, *viz.*, the base *A*, lever support *B*, and lever pivot *C*, and the indicating lever *D*. The body of this gage is made in two parts to facilitate machining. The indicating lever support is fastened to the body with cap-screws and dowel pins, and extends into the cylinder, so that the center of the lever pivot is somewhat below the face of the flange, as shown. By placing the

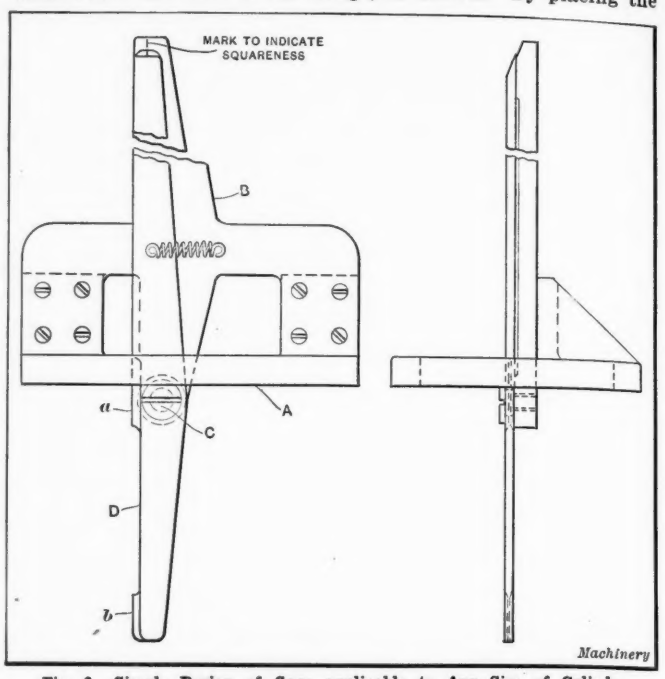


Fig. 6. Simple Design of Gage applicable to Any Size of Cylinder for testing Squareness of Bore

gage on the cylinder flange and bringing the knife-edges *a* and *b* of the lever into contact with the cylinder wall, any variation is shown by the mark at the upper end of the gage. The center of pivot *C* is placed below the face of the cylinder flange, so that when the indicating arm is moved against one side of the cylinder bore, the thrust will be taken directly by this pivot; as the lower end of the lever is held against the cylinder wall by a spring above the pivot, contact is insured at both points. This gage has solved the problem of testing cylinder bores, and it is in daily use in a factory where thousands of cylinders are produced every month.

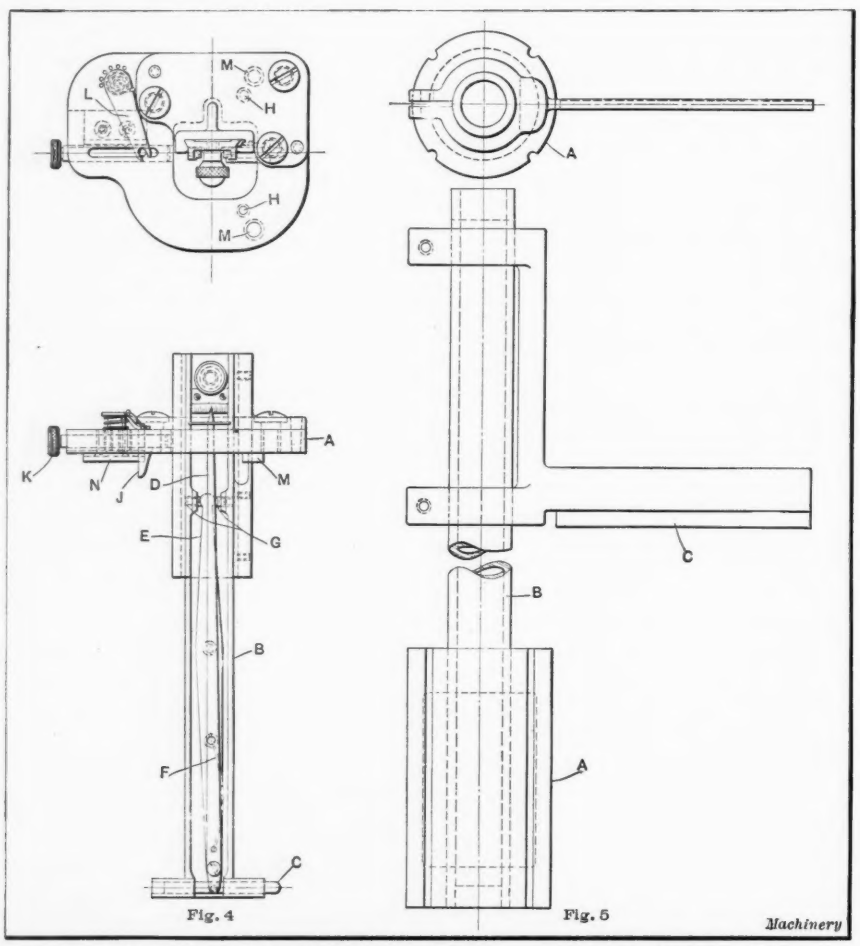


Fig. 4. Expensive and Complicated Type of Gage. Fig. 5. Simple Form of Gage for testing Squareness of Bore

* * *

WATERPROOFING CONCRETE

The College of Engineering of the University of Wisconsin is conducting a series of tests on the permeability of concrete. The object of the tests is to find a simple means of making concrete water-tight. The work shows that there is considerable difference in the imperviousness of concrete when the sand is dry and when the sand is wet before mixing. Good results are obtained if the concrete remains in the mixer from two to three minutes when dry materials are employed, but when the sand and gravel or stone are damp a considerably longer time is required. Therefore the use of wet sand should be avoided if possible. Experiments showed that mixtures consisting of 1 part cement, 1½ part Janesville sand of the "torpedo" grade and 3 parts Janesville gravel, when mixed to a wet consistency, are impervious to water under a pressure of 40 pounds per square inch. Mixtures as lean as 1 part of cement to 6 parts of gravel (graded mixture) have been made impervious by using care in proportioning the amount of water.

* * *

More than 800,000 horsepower has been developed from streams on national forests under government regulation. This is the output under conditions of lowest stream-flow.

MILLING FIXTURE FOR ANGULAR WORK

BY L. J.

The fixture which it is the purpose of this article to describe was designed for milling the sides of the block shown in Fig. 1. Three operations are involved; the parallel sides *A* are milled by means of the straddle cutters and the two sides *B* and *C* are then milled in two subsequent operations. These three operations are all performed without requiring more than one setting of the work. The block is cut off from bar stock, and drilled and counterbored to receive two fillister head screws which hold it in place on the machine of which it forms a part. These holes are also utilized for holding the block in position on the fixture.

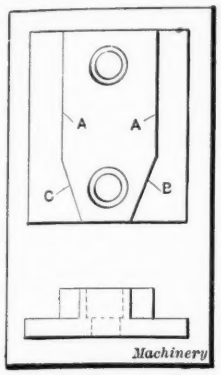


Fig. 1. Piece to have Sides A, B and C milled

Fig. 2 shows plan and sectional views of the milling fixture which consists of an upper plate *A* which is pivoted on the stud *B*. This stud is mounted in the cross-slide *C* which runs on the base *D*. The plate *A* is provided with two tapped steel bushings which are a forced fit in holes drilled and counterbored for the purpose. These bushings receive the two screws which secure the work in position on the fixture, their purpose being to prevent the rapid wear of the threads which would take place if they were tapped directly into the cast iron. Fig. 2 shows the fixture set in position for milling the parallel sides *A* of the work. Referring to the illustration it will be seen that there are two tapered pins *E* and *F* which are used for locating the work in the required position. For milling the parallel sides of the work, the pin *F* is inserted in the hole *N* to locate the cross-slide *C* in the required position. Similarly the pin *E* is located in the central hole to locate the swivel plate *A*. These pins are merely used to locate the fixture, the bolts *G* and *H* being provided to secure it in the required position. Fig. 3 shows an end sectional view of the fixture set in the same position as in Fig. 2, and by referring to this illustration a better idea of the operation of the fixture will be obtained.

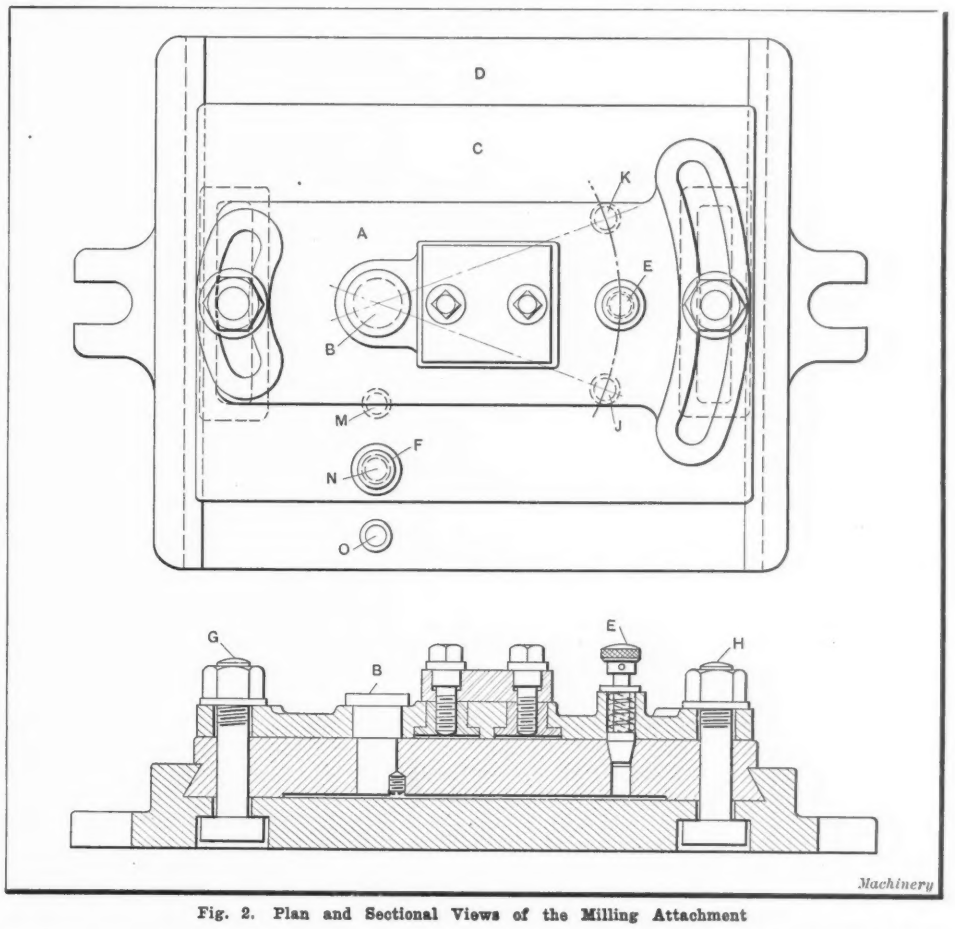


Fig. 2. Plan and Sectional Views of the Milling Attachment

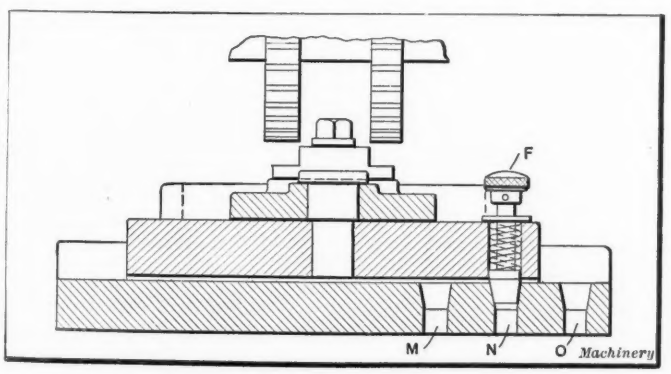


Fig. 3. Attachment set for milling Sides A of the Work

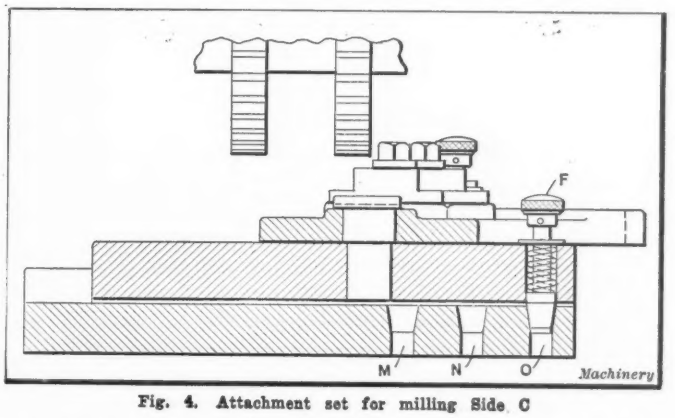


Fig. 4. Attachment set for milling Side C

Fig. 4 shows an end sectional view of the fixture set for milling the angular side *C* of the work. For this purpose the pin *E* is inserted in the hole *J* and pin *F* in the hole *O*. This sets the swivel plate *A* at the required angle and also locates the cross-slide *C* at the required distance off center to enable the work to be milled by the outer edge of the cutter, as shown in Fig. 4. After this operation has been completed the swivel plate *A* is swung over to enable the pin *E* to enter the hole *K*. Similarly the cross-slide *C* is moved so that the pin *F* will enter the hole *M*. This brings the work in position to enable the angular side *B* to be milled by the outer edge of the other cutter on the arbor.

* * *

LARGE HYDRO-ELECTRIC POWER DEVELOPMENT

The Chattanooga & Tennessee River Power Co.'s hydro-electric development at Hale's Bar on the Tennessee River near Chattanooga was formally opened and dedicated November 13. This is the largest hydro-electric power development in the South and one of the four greatest in this country, ranking with those at Keokuk and Niagara Falls. The power dam and lock were designed and constructed under the supervision of the U. S. Government Engineers at a cost of $9,000,000 and seven years was required to complete them. The length of the dam is 1200 feet and the lock is the highest single lift in the world, the height of the down stream gates being 58 feet. The lock, inside, is 60 by 310 feet and the power house 356 feet long; 65,000 H. P. will be generated.

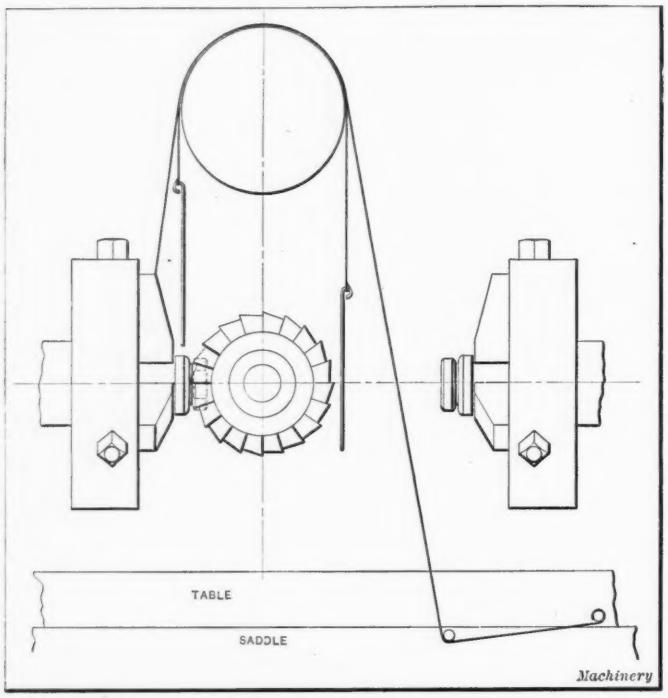
LETTERS ON PRACTICAL SUBJECTS

We pay only for articles published exclusively in MACHINERY.

A PROBLEM IN "HEXING"

In the How and Why section of the October number of MACHINERY H. L. B. asked for information concerning a good and cheap method of forming hexagons on machine steel pieces. A multiple jig for milling hexagons on six pieces simultaneously was illustrated and described in MACHINERY some time ago. Aside from the expense of making a jig of this nature, the time required for loading the jig, indexing and removing the finished work is so high, as compared with the actual time required for milling, that the output is not as great as might be expected. The following method requires no special tools or equipment, aside from the guards which protect the operator's hands while setting up the work in the chucks, and if a milling machine is used which has a feed reverse in the table, a close approach to continuous milling is obtained.

The two chucks shown in the illustration are mounted on plain index heads, and a pair of 3½- or 4-inch straddle milling cutters are set up on the arbor of the machine. The guard plates and cords for protecting the operator's hands while setting up work are shown more with the idea of suggesting what is necessary in this way than with the view of presenting a final solution of this part of the problem. Some more rigid device would be desirable, the only essential feature being that the plates should be moved into place and withdrawn alternately, in order to have the plate interposed between the milling cutters and the chuck in which a fresh blank is to be placed. The heads should be set as close together as possible, just sufficient room being allowed to provide for inserting the



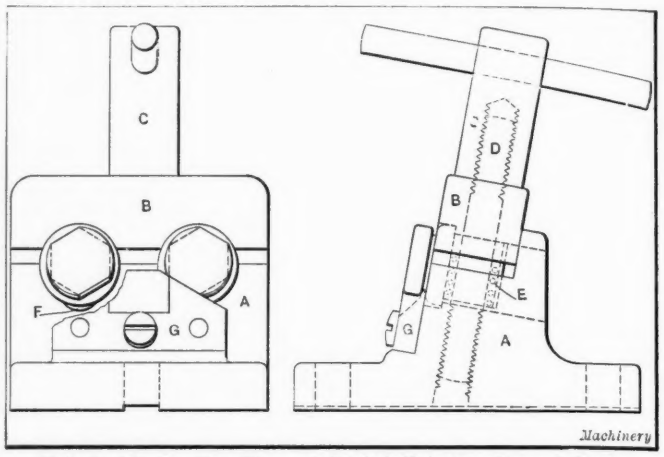
Method of hexing Work where Two Single Chucks are used

blanks and removing finished pieces. For the work that H. L. B. refers to, a 2½- or 3-inch movement of the table ought to be ample. It will be evident that the cutters will be working on the piece held in one of the chucks while the other piece is being indexed or while a finished part is being removed and replaced with a fresh blank.

Philadelphia, Pa. C. W. PITMAN

The writer believes that H. L. B. would find the use of two milling fixtures of the type shown in the accompanying illustration to constitute a satisfactory solution of his problem in hexing. Referring to the illustration, it will be seen that the fixture consists of a body *A* in which two pieces of work are held by the clamping cap *B*. The method by which this cap is tightened through a nut *C*, that is turned on the stud *D* by means of a handle, will be evident from the illustration. A coiled spring *E* is provided to lift the cap off the work when the nut is released. The holes in which the two pieces of work rest are bored all the way through and counterbored to receive the large diameter of the work; the shoulder at the bottom of the counterbore serves as a stop and the thrust of the cut is carried by it. It will be seen that the two holes are grooved as shown at *F* in order to afford a better grip on the work.

The locating plate *G* is removed while performing the first operation, although it need only be removed from one of



Method of hexing Four Pieces of Work held in Two Opposed Chucks

the fixtures. As the work comes from this fixture, the pieces are set up in the other fixture to have the second operation performed on them. When a sufficient number of pieces has accumulated, the locating plate *G* is replaced and both fixtures are used for performing the third operation, which finishes the work.

Two pairs of straddle milling cutters of about 3½ inches diameter by about ⅜ inch face are used. The inner pair of cutters works in the slot in the plate *G* while the outer pair works at either edge of the plate. The cutters are narrow enough to clear the screw which holds the plate *G* in position on the fixture, and their diameter is such that it is just possible to mill the "hex" without interfering with the flange on the work. The object of inclining the fixture is to provide greater convenience of operation which includes ease of cleaning, more room between the clamping handle and the overhanging arm of the milling machine and a better view of the work.

The fixtures are bolted to the table so that they face each other at either side of the spindle. They are located as close to the spindle as it is possible to have them and still provide room to safely remove the machined plugs and insert fresh blanks while the cutters are operating on the work in the opposite fixture. The power feed of the table is tripped by the regular feed-stops which are applied when the cutters have finished their work on the "hex." At this point the cutter will be within about 1/32 inch of the flange on the work, but although there is little room to spare, it is entirely practicable to operate a machine that is in good condition in this way. When one side of the milling cutters becomes dull, they can be reversed on the arbor, thus increasing the length of time that they can be used between grindings.

Watervliet, N. Y. MARTIN H. BALL

In reply to H. L. B.'s problem in hexing presented in the How and Why section of the October number of MACHINERY, I offer the following solution. The method has the distinction of being cheap when the possible output is considered, and may also be of value in suggesting a still better method. The fixture used for this purpose is shown in Fig. 1, where it will

be seen to consist essentially of two plates *A* and *B*. The upper plate is drilled to receive thirty-six studs, upon each of which a piece of work can be mounted. The base is provided with four lugs *C* by which it can be bolted to the table of the milling machine, and the upper plate is held down by means of three bolts *D* fitting in lugs on the upper and lower plates.

Each row of pieces is milled by straddle cutters and after two sides of the hexagon have been finished in this way, the work is indexed through 60 degrees by means of the taper pin *E* which fits into either of six holes in the base of the fixture. Three holes would really suffice for this purpose, but six are used in order to distribute as far as possible any wear which would develop. It will also be noticed from the illustration that there are cored recesses *F* under the holes in the base of the fixture which provide for the use of a drift to force out the index pin. A projection *G* on the plate *A* extends into an opening in the base *B* in order to hold the two plates in alignment while they are being indexed.

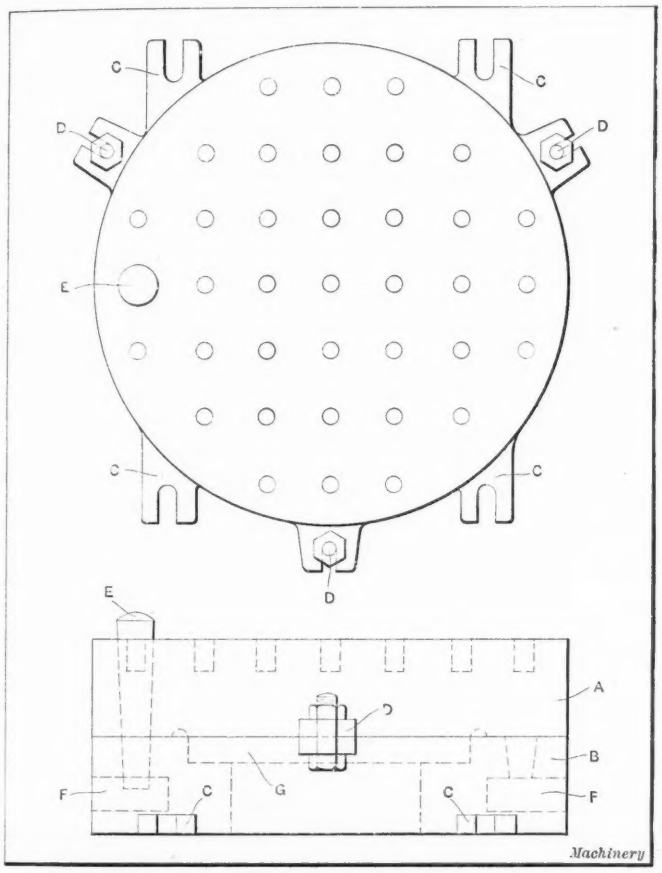


Fig. 1. Design of Multiple Fixture for milling Hexagons

Several methods may be used for holding the work in position on the fixture. One of the simplest devices for this purpose consists of the use of studs over which the work is slipped and held by a nut and washer. A convenient form of stud for this purpose is shown in detail at *B* in Fig. 2. The nut on this stud is made of such a size that the work will slip over it. It will be seen that the washer has a slot milled in it so that it may be slipped into place without requiring the nut to be screwed all the way off the stud. This greatly facilitates the rapidity with which the work may be set up or removed. The studs should be hardened and ground to increase their durability, and it is a good plan to use a bushing in the counterbore of the work, in order to provide for having it held snugly on the stud. Another good method of holding the work in place is by means of split bushings of the form shown at *A* in Fig. 2. These bushings are an accurate fit in the bore of the work and extend into reamed holes in the face of the fixture. When the work has been set up on these bushings, taper pins are driven in, which expand the bushings and hold the work securely in place. If this method is used, the upper plate *A* would be considerably thicker and provided with cored recesses to permit drift pins to be used for ejecting the taper pins.

A similar arrangement of simpler design could be made by mounting five studs in a bar to provide for milling five pieces simultaneously. A bar with the work mounted on it would be placed in the milling machine vise and the work milled by means of straddle cutters. After taking the first cut, the vise—which must have a graduated base—is swung through 60 degrees, after which the second cut is taken. The vise is then swung back through 120 degrees to locate the work ready for taking the third cut, which completes the operation. This method has nothing to recommend it but the reduction in the initial cost of the fixture.

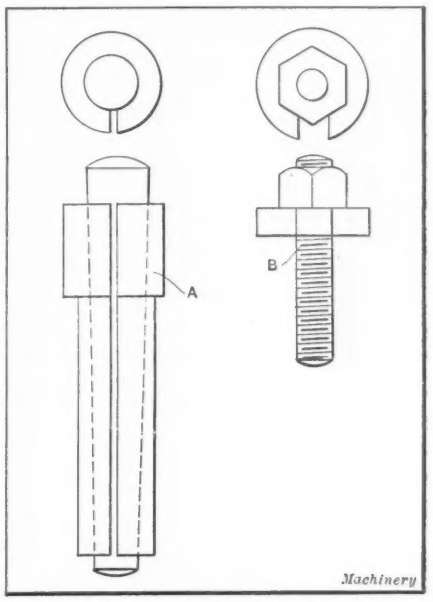


Fig. 2. Details of Two Methods of holding Work

Stillwater, Minn. R. C. MacLachlan

Some time ago the writer saw a hydraulic press rigged up for making semi-steel gears, and it appears that the same idea might be used to advantage in solving H. L. B.'s problem in hexing, which was presented in the October number of Machinery. The writer has not had any experience with this particular class of work, but a wide experience in toolmaking leads him to believe that it would be entirely practicable. The design for a die for handling this operation was taken up in exactly the same way that any other new operation coming into the shop would be handled, the idea being to turn out the work with the least possible expense for tools and labor.

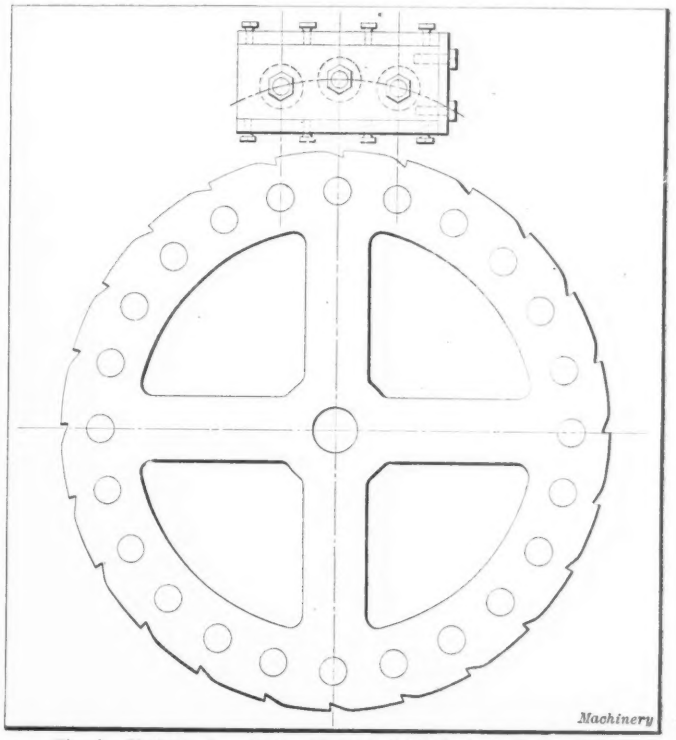


Fig. 1. Method of producing Hexagonal Heads in a Power Press

The preliminary work in producing these pieces would be an ordinary screw machine job, the order of operations being to form the piece, drill the small hole, counterbore and then cut off. After the pieces had been produced in this way, they would be transferred to a punch press equipped with dial feed and a die of the kind shown in Fig. 1. A detailed view of this die is illustrated in Fig. 2, from which its construction will

be better understood. Referring to this illustration, it will be seen that there are three openings in the die laid out on a circle of the same radius as that of the circle on which the work is set up on the dial of the punch press.

From the dimensions given by H. L. B., it appears that there is about 5/64 inch of metal to be removed from the sides of the "hex." To get a good finish, it would be desirable to take this cut in three steps: first roughing cut, 1/32 inch; second roughing cut, 1/32 inch; finishing cut, 1/64 inch. The three dies are graduated in sizes to take these three cuts. The dial is indexed by means of the usual ratchet mechanism so that the work is advanced from die to die between strokes. In this way one piece of work will be finished at each stroke of the press after the first two strokes have been made. It would be entirely practicable to rig up some form of ejecting mechanism which would knock the finished pieces of work out of the dial. With such an arrangement the operator would merely have to sit in front of the press and mount blanks in the holes which had been left vacant by the removal of the finished pieces of work.

Referring to Fig. 2, it will be seen that the three dies are equipped with pilots which assist in holding the die in the desired alignment. It will also be seen that each die is provided with a stripper which is backed up by a stiff spiral spring that ejects the scrap from the die after each stroke. The stripper also serves to hold the work in place in the index wheel. In producing "hexes" in this way, it would doubtless be a good plan to have two dies to fit into the punch-holder. With such an arrangement one die could be sent to the toolroom to be sharpened and the other set up in position so that

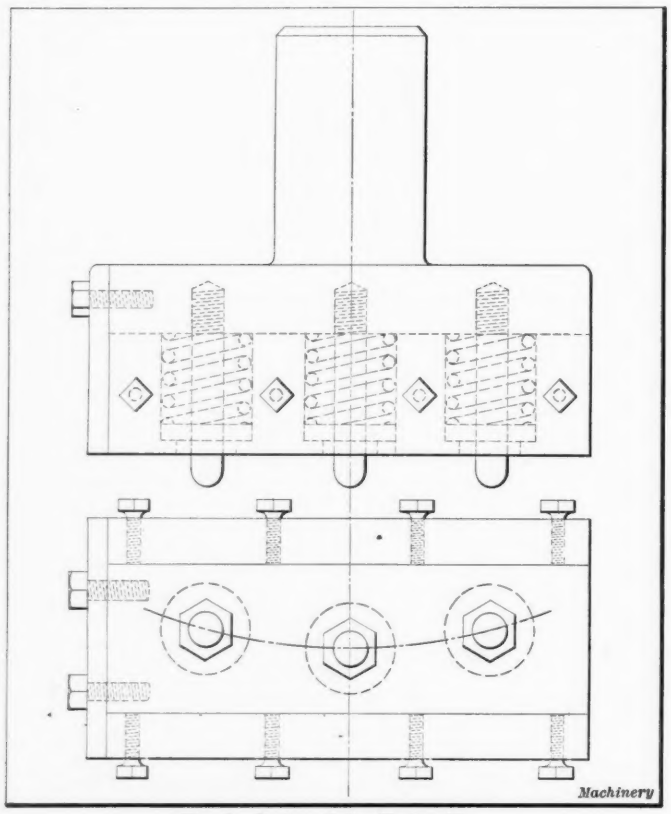


Fig. 2. Design of the Hexing Die

no loss of time would result. The end stop on the holder facilitates bringing the die blank into the desired alignment with the least possible loss of time.

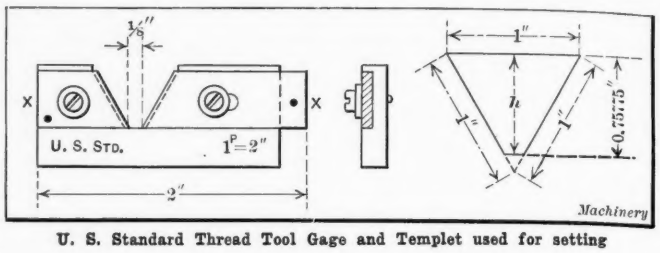
Beloit, Wis. O. F. PHILLER

[Suggestions for methods of handling this operation were also received from James R. Allan, Chicago, Ill.; Walter Butz, Pearl River, N. Y.; W. J. Kittle, Pearl River, N. Y.; P. S. Souders, Rockford, Ill.; E. Wanamaker, West Haven, Conn., and O. A. Webster, Readville, Mass.—EDITOR]

U. S. STANDARD THREAD TOOL GAGE

As most mechanics know, the U. S. standard thread has a 60 degree included angle and a flat at the top and bottom equalling ⅛ of the pitch. This means that the depth of a U. S. standard thread of a given pitch is equal to ¾ the depth of an ordinary V thread of the same pitch. It will be evident from the preceding that a thread of 1-inch pitch has a ⅛-inch flat at the top and bottom, and this is taken as the basis in constructing the present gage.

The decimal equivalent of ⅛ is 0.125. Suppose it is attempted to divide this number by 8 in order to obtain the flat on a U. S. standard thread tool with eight threads to the inch. The length of the flats in this case will be found to be 0.015625 inch, but it would be very difficult to make an accurate gage for a thread tool of this size. This difficulty has been entirely avoided by using a thread of 1 inch pitch for the basis in making the gage. Referring to the illus-



U. S. Standard Thread Tool Gage and Templet used for setting

tration, it will be seen that the gage consists of a body which has one jaw secured to it by a screw and pin. The other jaw is secured by a screw which passes through a slot in the jaw, so that this jaw may be adjusted longitudinally to adapt the gage for different pitches. The jaws run in a slot machined in the body of the gage so that they are kept in the desired alignment, and the end of the tool is brought up against the body. The gage is set for different pitches by measuring the distance between the outside ends of the jaws with a micrometer.

In order to obtain the proper location of the angular sides of the two jaws when they are together for a one-pitch V-thread or open for a U. S. standard thread tool of the same size, a templet was made of the form shown at the right-hand side of the illustration. This templet was first made an accurate equilateral triangle with sides 1 inch long, and one point was then cut off to make the height h exactly 0.75775 inch. The jaws were then adjusted so that they fitted against this templet with one of the sharp points in position, which corresponded to the setting for an ordinary V-thread, and with the cut-off point in position when the setting is that for a U. S. standard one-pitch thread tool. When set for a one-pitch V-thread, the distance between the ends of the jaws, as obtained with the micrometer, is 1.875 inch; and for a one-pitch U. S. standard thread, 2 inches.

A convenient method of setting the gage is to open it a small amount more than is required and then partially tighten the screw which holds the movable jaw. The micrometer is then put over the ends of the gage and screwed up to the required dimension, carrying the movable jaw with it. After the setting has been obtained in this way, the binding screw which holds the movable jaw is tightened up. It will be evident from this description that the gage is easily set by any man who knows how to use a micrometer.

Springfield, Mass. FRANCIS W. CLOUGH

SETTING DIAMONDS

I have read with much interest the short articles which have been published in MACHINERY relating to methods of setting diamonds. After trying nearly all of these, I decided that setting the diamond in a piece of copper and forging the metal tight around the stone was the most satisfactory for average shop conditions. We use a large number of small diamonds for scoring glass tumblers before they are put into the heat to be cracked off. These diamonds require careful setting as they must make a clean accurate mark.

I would be interested to hear from readers of MACHINERY what they have found to be the best method of selecting a diamond. This, to my mind, is of more importance than the method of setting. My own practice has been to look at the stones carefully under a magnifying glass and choose those that are the closest grained and of a glossy black appearance.

Some black diamonds are just like pieces of coke—full of small pores. I once set one of these stones that cost $60 and it ground away like graphite. What I would like to know is whether the color has anything to do with the quality of the stone because in all of the different diamonds that I have looked at, the color varied from a deep black down to a dark gray. By way of conclusion, I would say that I have not yet met an agent who would guarantee a diamond.

Bridgewater, Pa. J. TOWLER

ON CLEANING MACHINES

Some time ago I read about a technical school workshop in which the machines were all finished in white enamel. I should like to know if the boys keep these machines clean, or if the cleaning is done by a special attendant. So far as my experience goes, it is about as difficult to teach a boy to clean a machine tool and leave it in passable order at the close of a lesson as it is to teach him anything else.

Finally it began to dawn on me that I was expecting too much from the boys. I saw girls being put through an elaborate course of training, requiring many months, a large part of which consisted in teaching them to keep a house, its furniture and utensils clean. They were drilled in the washing of dishes, pots, pans and tables, day after day, until in place of the gawky little slatterns who entered school a year before, you were dazzled with the trim smart capable young persons who would strike terror into the heart of any ruffian who dared to enter a house without first leaving his boots on the mat outside.

Evidently, the boys needed more elaborate drilling in the cleaning and general order of machines and tools, even though it shortened the time available for their regular work. Such training is most important, however, as a machine which is kept clean and tidy gives less trouble and lasts longer than one which is neglected. A good illustration of this was afforded me a number of years ago, when I was sent to repair a small steam engine which was continually breaking down. I found it located in a dark and dirty shed, smothered in old grease and soot. I gave the attendant a few scrapers and started him on the job of cleaning it while I dismantled the defective parts. After a few hours' work, he announced that it was clean. I directed his attention to parts on which he had not reached the original coat of paint, and he started again. This process was repeated several times during the period the engine was under repair. At last he began to take notice of things himself, and, to my gratification, suggested cleaning and whitewashing the shed and giving the engine a coat of paint. This was done and I left him in charge of an engine which he had cleaned and painted and polished, and of which he was proud. That engine gave no more trouble until it was superseded by a more powerful one some years later.

Christchurch, New Zealand. JOHN PEDDIE

LUBRICANT FOR WORM-GEARS

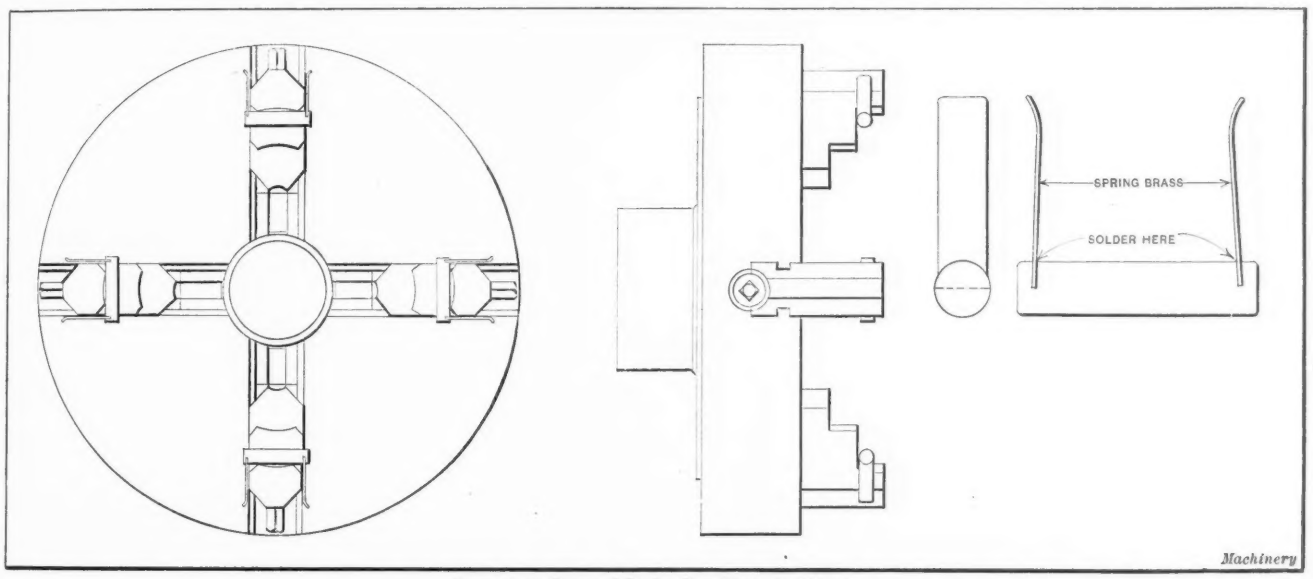
No doubt many readers of MACHINERY have had trouble with worm-gears even in cases where the gears ran in oil. In the majority of installations, the worms are cut from steel while the worm-wheels are of cast iron. The writer has had a lot of experience with worm-geared elevator hoists and gives below a very satisfactory formula for a lubricant which is composed of the following ingredients: Cylinder oil, 2 gallons; common flour, 1 pound; common salt, ½ pound.

It will be found that the flour will make the oil heavy enough to stick while the salt will so glaze the worm and gear that they will run smoothly without any tendency to "score." In extreme cases, where the worm-gear runs hot, owing to continuous and fast running and to friction, it is sometimes advisable to add to the above ½ pound of graphite. The lubricating and cooling properties of graphite are too well known to require discussion. Anyone who has had trouble with worm-gearing will find this lubricant well worth trying.

Decatur, Ind. HARRY FRITZINGER

LATHE JAW DISTANCE PIECES

Machinists, and especially toolmakers, frequently have occasion to set up a job with the work set out from the faces of the lathe jaws. Distance pieces are commonly used for this purpose and various methods are resorted to in order to hold them in place. The accompanying illustration shows the type of distance pieces that I have used for a number of years. They are made from pieces of round drill rod 5/16 inch in diameter and about ¼ inch longer than the width of the chuck jaws. A slot is sawed half way through the drill rod at each end and flat strips of brass are soldered into these slots. The brass pieces are bent to the form shown in the illustration, so that they grip the chuck jaws firmly enough to hold the distance pieces in place.



Convenient Form of Lathe Jaw Distance Pieces

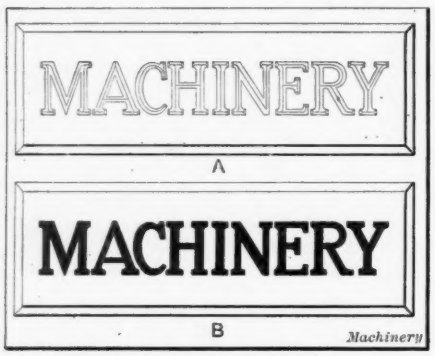
Delphos, Ohio. A. J. BRICKNER

IMPROVED METHOD OF MARKING MACHINE PARTS AND TOOLS

The method of marking machine parts, referred to in this article, is for producing brass letters, numbers, designs, etc., on steel, iron and brass. In addition, this method is very effective for making name-plates, such as are used on front doors of apartment houses and hotels. The desired result may be obtained in various ways, a few of which are given in the following:

The first step is to see that the part to be marked has a true surface, free from rust and dents. The name, or number, is stamped on the work by means of steel letters, or a steel stamp as indicated at *A* in the illustration. The only precaution necessary to take in stamping the letters or num-

bers, is to have them as deep as possible and all of the same depth. A coating of molten brass is next distributed over the entire surface of the work by the common process of brazing, plenty of flux being used. The work is then allowed to cool, after which it is ground on a grinding machine, or by other means, in order to remove the surplus brass from the surface. This operation leaves the brass only in the letters or numbers that have been previously stamped on the work. After the surface is polished in the usual manner, the letters present a very pleasing appearance. The view *B* illustrates the plate after grinding. If it is desirable to give the letters a bronze appearance, the work, after polishing, should be immersed for a few seconds in a solution of equal parts of nitric and hydrochloric acids.



(A) Stamped Name-plate
(B) Stamped Name-plate with Brazed Brass Letters

Another method is to first outline with a pencil, the name or design, on the surface of the steel or iron to be marked. The outline is then gone over carefully with a center punch, the punch marks being made as close together as possible without touching, and about one-sixteenth inch deep. After the work is brazed and polished, as previously explained, the letters have the appearance of being formed of inserted brass plugs.

Still another method is to etch the name or design on the steel, by means of a suitable acid, after which the foregoing procedure is followed. It is necessary with this method, to boil the work for a few minutes, in soda water, before brazing, to remove any trace of the acid from the letters or design.

To stamp brass with "steel" letters, the same method may be employed, with the exception that solder is used to fill up the letters. Any common soldering acid or paste may be used as a flux for this purpose.

The methods given in this article, may, of course, be changed somewhat to suit requirements, and many new methods substituted; the work will be found very attractive, and "*out of the ordinary*."

East Orange, N. J. GEORGE GARRISON

AUTOMOBILE REAR AXLE DESIGN

I have just finished reading the article entitled "Automobile Rear Axle Design" that appeared in the September number of MACHINERY and have several criticisms to offer. The equations that appear immediately above Fig. 4 should read:

$$TI = Q\,r\,\mu$$

and for one wheel

$$\frac{TI}{2} = \frac{Q\,r\,\mu}{2}$$

Some designers make a great mistake in assuming that if one wheel is locked by the greater frictional resistance of the road or by getting wedged in a narrow rut, the other wheel takes the full torque *TI*. Such is not the case. When one wheel is completely locked, the differential mechanism causes the other wheel to rotate at twice its ordinary speed, and hence the torque drops to $\frac{TI}{2}$.

In the equation below Fig. 5, the coefficient ½ should be inside the parentheses, as it does not refer to the tension of the driving chain. But the quantities $\frac{Q\,r\,\mu}{2}$ and the tension of the driving chain cannot be added together, as they are different quantities, the first being a moment expressed in inch-pounds and the second a force expressed in pounds. If anything, this expression should be:

$$M_2 = A_2\left(\frac{Q\,\mu}{2} + \text{tension of driving chain.}\right)$$

The $\frac{Q\,\mu\,A_2}{2}$ is all right but the tension of the driving chain should be multiplied by a lever arm A_3, which is the distance from the center line of the chain to the center line of the radius rod, as shown in Fig. 2. Then

$$M_2 = \frac{Q\,\mu\,A_2}{2}$$

$$M_3 = \text{tension of driving chain} \times A_3$$

The resultant bending moment M of the axle is then given by the following:

$$M = \sqrt{(M_2 + M_3)^2 + M_1^2}$$

Further on in the article the expression occurs:

$$\text{Torque of ball} = \frac{43{,}200}{60} = 720 \text{ pounds.}$$

The term "pressure" should be used in place of "torque." If the quantity was a torque, the result would be expressed in inch-pounds.

I do not agree with the way in which the force *F* on the housing pin is figured. As shown in Fig. 5, the torque rod, the housing torque boss, and the torque rod pin form the familiar type of hinge construction. As such, the pin is subject to a shearing stress in the planes of the joint, which are found to be 7.5 inches apart by scaling the drawing. Regarded in this light, the magnitude of the shearing force will be:

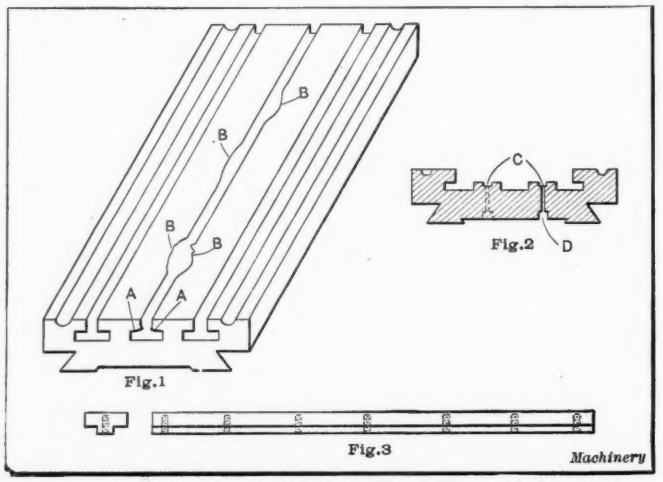
$$F = \frac{720 \times 56\frac{3}{8}}{7.5} = 5400 \text{ pounds.}$$

Mr. Najder does not state whether he regards the stress as a bending or a shearing stress, but as he uses the distance of 10.75 inches between the centers of the bearings supporting the pin, it appears that he is figuring for bending. As a matter of fact, there can be no bending action on the housing pin, as it invariably forms a press fit in the torque rod and a nice sliding fit in the housing torque boss, which is generally lined with an accurately reamed bronze bushing. If Mr. Najder had a shearing force in mind, the illustration is wrong; and if the illustration is right, he must have based his analysis upon the assumption that the pin was subjected to a bending stress.

Flint, Mich. M. TERRY

REPAIRING A MILLING MACHINE TABLE

The milling machine table shown in Fig. 1 has been broken at *A* and *B* through the use of common bolts for clamping the work in position. Tables are frequently damaged in this way when the remainder of the machine is in good condition; hence a method of making a satisfactory repair is of considerable value. The method which I developed for this purpose may be briefly described as follows: The two bars which form the T-slots were planed off, after which two



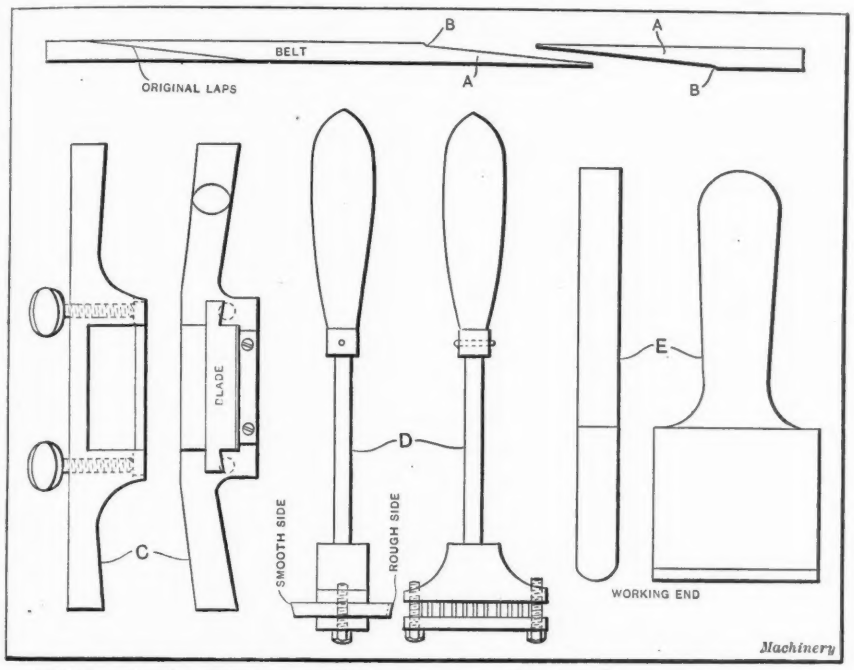
Figs. 1 to 3. Method of repairing a Broken Milling Machine Table

grooves were planed as shown at *C* in the sectional view, Fig. 2. Two bars shown in Fig. 3 were next planed up with extensions to fit into the grooves *C* in the table. When this work had been done, the table was turned over and the bars put in place under it, after which seven holes *D* were drilled and tapped in each bar to provide for holding the bars in place by countersunk screws. Hexagon cap-screws were used for this purpose. With the bars secured to the table in this way, a very satisfactory repair was made.

New York City. MAX HIMOFF

PREPARING AND CEMENTING BELTS

The cementing of endless belts—either new ones or old ones that have parted in service—is not as well understood as it might be by the average mechanic. With the view of explaining the method of procedure in cementing belts for the benefit of men employed in shops where there is no regular repair man, the following article has been written. In order to prepare an old belt that is greasy, the first step is to clean is thoroughly by soaking in benzine for about fifteen minutes. The belt is then laid out flat on a board or bench to allow it to dry. The ends that are to be joined should be further cleaned by placing blotting paper over and under them and then applying a hot iron to soften the grease so that it will be absorbed by the blotting paper. It is, of course, understood that a clean new belt does not require this treatment.



Method of forming Belt Laps and Tools used for the Forming and Cementing Operations

In the case of a new belt, the belt should be fastened to a board or bench and the ends beveled as shown at *A*, the tools *C* and *D* being used for this purpose. The tool *C* is employed to rough down the ends to shape and the smooth side of *D* is used to scrape the end of the lap to produce the shoulder *B*. The rough side of the tool is then brought into action to rough the surfaces to be joined so that they will take the cement. In beveling the ends of the belt, care should be taken to see that the finished lap will run in the same direction as the original lap in the belt, the length of the lap being determined from the length of the original lap of the old belt.

A good cement for joining the ends of a belt is cheapest, as a cheap cement is dear at any price. A good cement can be made from the following formula: Peter Cooper's white glue, 1 pound; powdered white lead, 1 ounce. This glue is heated in a double boiler and thoroughly stirred until it forms a thick paste. Before using, the paste is thinned down the required amount with grain alcohol until a thin paste is formed. This paste is applied hot. After joining the ends of the belt, the joint is rubbed with the end of the wooden spatula *E*, taking care to apply pressure over the entire lap. Two small pieces of board can be clamped or nailed over the joint, after which the belt is placed in a warm, dry corner away from drafts. The joint should be allowed twenty-four hours to set before it is used.

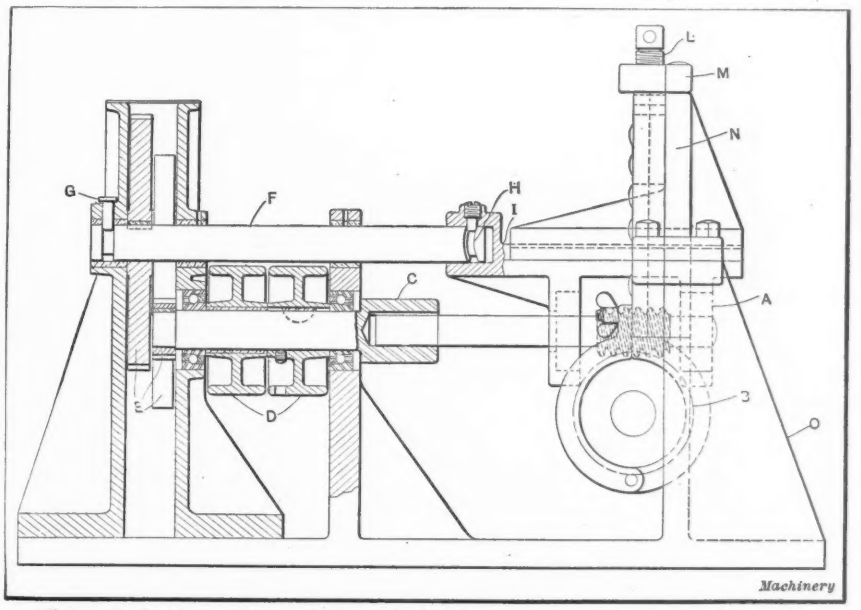
New Britain, Conn. W. C. BETZ

WORM AND WORM-WHEEL LAPPING FIXTURE

There is no part of an automobile that requires more careful attention than the steering gears. It is essential for these gears to be designed to meet the requirements of the particular car on which they are to be used, and to keep the cost of production within certain limits. There are several types of steering gears that may be used, among which may be mentioned the worm and segment, the bevel gear and bevel segment and bevel gears. The most universally used type is the worm and worm-wheel.

In manufacturing these gears the best grade of high-carbon machine steel, nickel steel, chrome-nickel or chrome-vanadium steel is used. These steels all forge well and are easily machined. They are always carbonized and hardened to give the greatest strength and wearing qualities. It is during this hardening process that strains are set up which cause the steel to warp. No matter how accurately the parts may have been machined, they will be distorted by the heat-treatment to such an extent that many cannot be used. It was to overcome this distortion that the fixture shown in the accompanying illustration was designed. By grinding or lapping the worm and worm-wheel together, it was found that the uneven spots which caused the steering wheel to turn harder in one position than another were removed, and the wheel would then turn smoothly and easily.

After a worm and worm-wheel have been used on a car for some time, it is necessary to adjust the worm and wheel to take up end motion. Therefore it is essential for more than one thread on the worm to be lapped to the wheel. It is for performing this lapping operation that the present fixture was designed. For this purpose the worm is placed



Fixture for lapping a Worm and Worm-wheel to insure having them run smoothly together

in the fixture at *A* and the wheel at *B*. The end of the worm-shaft is fitted to the driving shaft *C*; this driving shaft carries tight and loose pulleys *D* and a small gear which engages the train of gears *E* that operate the shaft *F*. The gears *E* run in an oil bath formed by means of the upright members of the fixture. The pin *G* fits in a groove at the left-hand end of the shaft *F* and prevents it from moving in an endwise direction, while a cam *H* is cut at the opposite end of the shaft *F*; this cam operates the slide *I* in which the worm is mounted. By means of this cam the worm receives an oscillating motion which laps enough of the thread to allow adjustment between the worm and wheel.

The worm-wheel is also clamped in an adjustable slide which is provided to allow various sized worm-wheels to be lapped in the fixture. Gibs provide an ample bearing for this slide, which is operated by the screw *L* which runs in the plate *M*. The casting *N* supports the gibs and forms the dovetailed bearing for the slide *I*. The base casting of the fixture is shown at *O*.

In using this fixture the worm is driven at about fifty revolutions per minute, and the gear reduction is such that the worm is removed longitudinally at about one-quarter the rate at which it revolves. This ratio allows the thread of the worm to engage each tooth of the worm-wheel, and the use of emery and oil for lapping gives a very smooth surface that insures even running between the worm and wheel.

Springfield, Mass. E. H. PRATT

REPAIRING AN AUTOMOBILE CYLINDER

The shop in which the writer is employed recently made rather an unusual repair on an automobile cylinder, and a description of this repair will, perhaps, interest readers of MACHINERY. The reason trouble was taken to repair the cylinder was because considerable time would have elapsed before a new one could have been obtained from the manufacturer; also, to make a new cylinder in a local shop would have meant a large expense in the preparation of patterns.

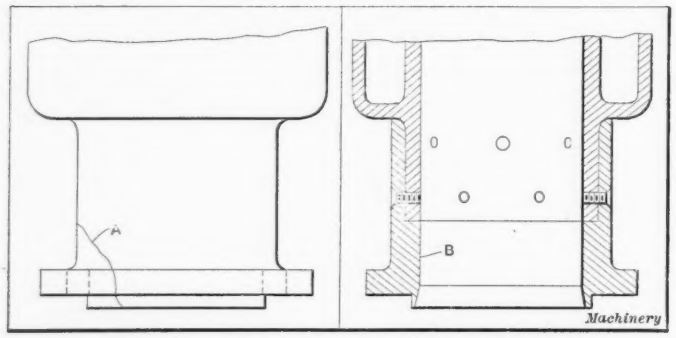


Fig. 1. The Broken Cylinder Fig. 2. Repaired Cylinder

The cylinder was broken through the bottom flange as the result of being bolted down unevenly to the crank-case. The position of the break may be seen at *A* in Fig. 1. In making the repair, the cylinder was first placed in a lathe, and the flange parted off at the break, as shown in Fig. 2. The outside diameter of the cylinder was next turned right up to the water-jacket, a light cut being taken to leave the wall as thick as possible. The casting *B* was then made and machined to go over the outside of the cylinder, and to fit up underneath the water-jacket. This casting was secured in place by means of eight manganese-bronze set-screws staggered around it. The reason the set-screws were made of manganese-bronze was because this material expands at practically the same rate as cast iron when it becomes heated, and so, although the set-screws penetrate to the inside of the cylinder, they will not score the piston. The holes for the set-screws were drilled and tapped into both the casting and the cylinder, and then countersunk. The set-screws were screwed home and the ends riveted over.

Before the original cylinder was touched the necessary dimensions were taken to make sure of the repaired cylinder having the same compression as the original. Up to the present time, the cylinder has not given any trouble.

Christchurch, New Zealand. J. H. CLARKE

A GROOVING TOOL

If one stops to study the problem that was presented when it was desired to machine the casting shown in Fig. 1 on an automatic turret lathe, it will be seen that a grooving tool will be needed which must not only be strong but very compact and accurate. Fig. 2 shows the design finally adopted, which has proved very satisfactory, both as to automatic action, strength and accuracy. Although rigid enough as it is, a pilot, of course, would add to its rigidity.

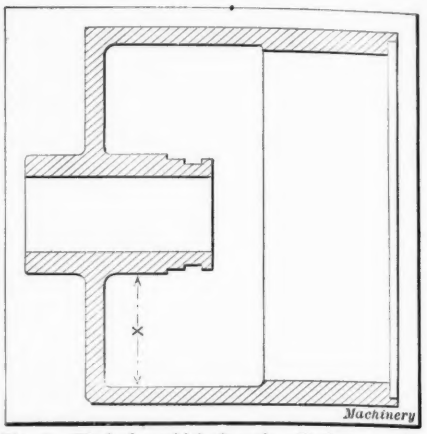


Fig. 1. Work for which Grooving Tool was made

The bar *A* is offset as shown at *B*, point *C* being the center of the lathe chuck and point *D* the fulcrum point of the tool-holder *E*, which is a steel casting bored to hold the tool *F*. This tool is set and held in the proper relation as regards its cutting edge by clamps *G* and nut *H*. It will be noticed that the tool *F* is so shaped that it will allow of much and inexpensive grinding, forestalling any possible objection to such an expensive cutting tool. The tool-holder *E* is free to move on the bar *A* up to a certain limit, and when this limit is reached, pin *J* will come into contact with screw *K*. It is necessary to adjust this screw very accurately, for upon it, more than upon the travel of the lathe carriage, depends the accuracy of this tool; it takes the backlash out of the cam, so to speak.

The lathe carriage, of course, also has an adjusting screw *L* which engages the surface of the plate *M* as the carriage moves inward and brings the tool-holder around, thus feeding the cutting tool into the work the required amount. The pull-back arrangement consists of a spring *N*, pin *O*, bracket *P* and adjusting screw *Q*. When we consider that this tool, from which so much is expected as regards rigidity and automatic performance, needs but 1½ inch working space at *X*, as shown in Fig. 1, it will be apparent that it is of excellent design.

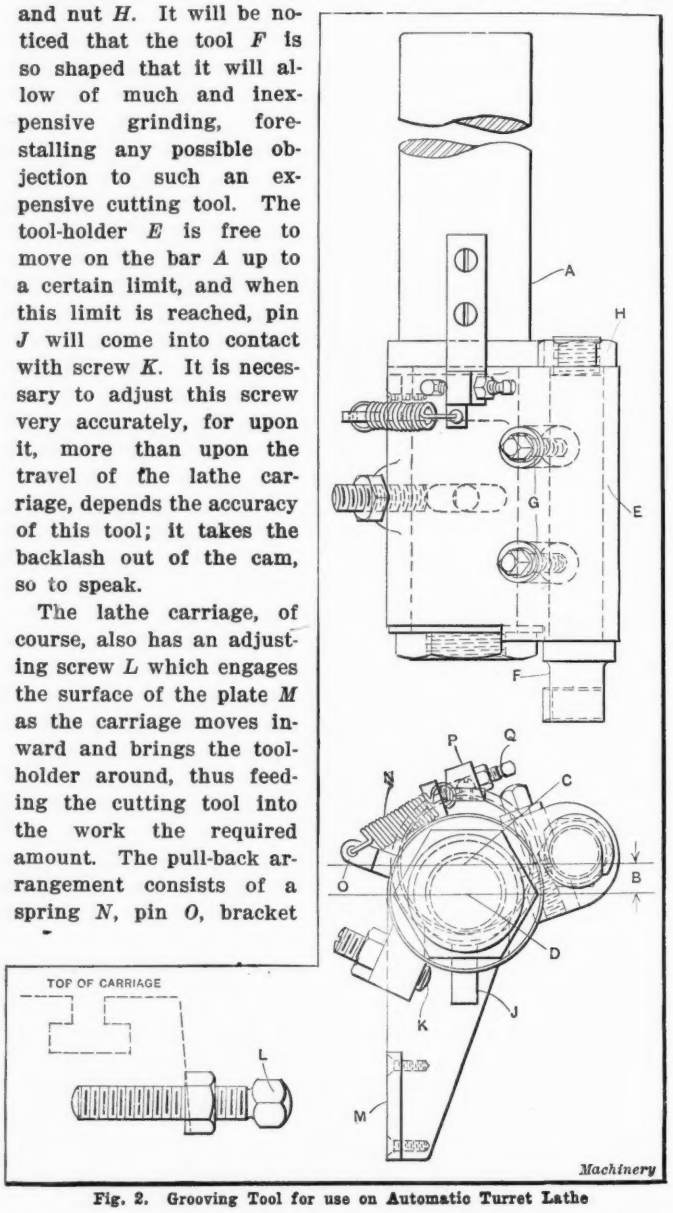


Fig. 2. Grooving Tool for use on Automatic Turret Lathe

RICHARD RUSSELL

"RELIEF OF TAPS"

In the December number of MACHINERY on page 263 (engineering edition) in the article, "Relief of Taps," is a misstatement of fact which we believe you should correct.

The form of relief shown in Fig. 13 is not new. We began making taps with that form of relief in March, 1885,

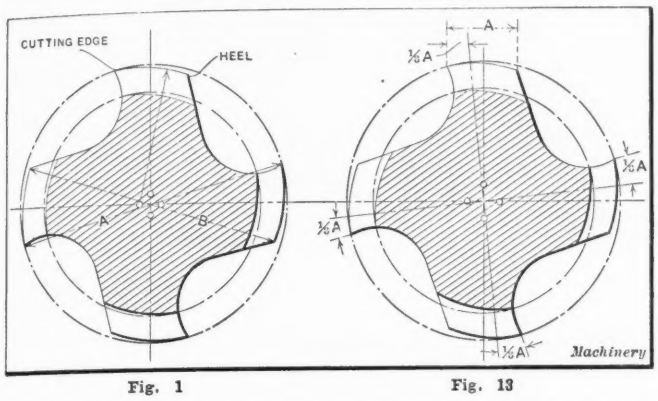


Fig. 1 Fig. 13

and have continued the practice ever since, calling the tap "machine relieved." One-third of the width of the land is concentric, that is, the top, angle and bottom of the thread follow the curve of the hole. The remaining two-thirds of the land is relieved on the top, angle and bottom of the threads.

Thousands of users of "Lightning machine relieved" taps will recognize the error into which your editorial department has fallen.

Greenfield, Mass. WILEY & RUSSELL MFG. CO.

[We are glad to publish this letter from the Wiley & Russell Mfg. Co., which is something of a revelation. The letter will remove the impression existing, we believe, not only among tap users but among tap makers that "Lightning" machine relieved taps are made with full eccentric relief, the relief beginning at the cutting edges of the teeth as shown in Fig. 1. We think that many users of "Lightning" taps are not aware of the fact that one-third the land is concentric and the remaining two-thirds eccentric, as shown in Fig. 13. The editorial department was never taken into the confidence of the company as regards the exact shape of thread relief used and was as much in the dark as to the details as the average tap user.—EDITOR.]

"RELIEF OF TAPS"

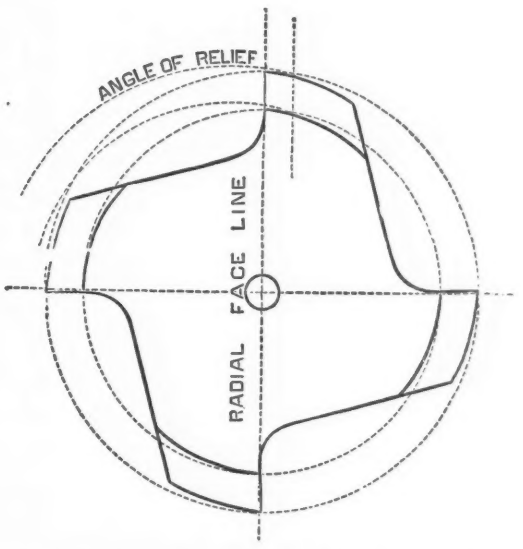
I have read with great interest the article in December MACHINERY entitled "Relief of Taps," and wish to endorse heartily the conclusion reached therein that the type of relief shown in Fig. 13 is the most practical and satisfactory form discussed. The article contains one error, however. The Pratt & Whitney Co. is wrong in its belief that it is the originator of this particular type of relief, when adopting it five or six years ago. I can testify, from personal knowledge, that this identical type of relief was used on the tap product of the Wiley & Russell Mfg. Co. during the whole time I was connected with them—a period of about eighteen years—prior to the retirement of the Russells from that company upon its reorganization about two years ago. I believe they still use it.

The accompanying cut and text are from a catalogue of the Wiley & Russell Mfg. Co. published about eight years ago, and will be found to describe accurately the same type of relief as shown in Fig. 13 of MACHINERY'S article. This catalogue clipping, while not giving the exact width of the concentric land, shows in the cut that the full diameter of the tap is maintained for approximately one-third of the land, and this, indeed, was our practice.

In that catalogue of eight years ago was first printed the description of our tap relief, but I have in my possession a Wiley & Russell catalogue of thirty years ago, which contains this phrase: "Our taps are all machine relieved on the most correct principle." This refers to the same type of relief as that we are now discussing, and was printed at about the time we began applying this relief by machinery during the process of threading. Even earlier than that, probably for a period of about five years, we had been applying this same relief to our taps by hand with a "three-square" file. While I cannot get from the records the exact date when this type of relief was first used upon the Wiley & Russell tap product, it is safe to assume from the above that it was at least thirty-five years ago.

The long experience of the management of our new organization, the Russell Mfg. Co., has so strongly convinced us

Lightning Machine Relieved Taps



The above diagram shows our Machine Relief, exaggerated to show the principle.

Every tooth, both top and bottom of thread, is relieved like a milling cutter This reduces friction and binding to a minimum, and produces a free, clean cut.

In this form of relief, the true size of the tap is maintained the full length of the flute; ample stock being left behind the cutting edge, so that it may be reground for sharpening many times without destroying the size.

This relief might also be termed a "parallel" relief, as the full threads are of the same diameter throughout and **absolutely parallel** from end to end.

The life of these taps is much longer than that of taps relieved by the common method, which have the true size only in the first few teeth at the point, the relief being gained by gradually reducing the size toward the shank. It will readily be seen that the size of taps, relieved in this way, is lost as soon as the teeth at the point wear down; and these teeth wear the fastest, because they do all the cutting.

Our relief is applied in process by special machinery, which insures absolute uniformity.

☞Index on pages 4 to 6

Reproduction of Page from Wiley & Russell Mfg. Co.'s Catalogue published about Eight Years ago

of the superiority of this type of tap relief over all others that we will use it upon our product as soon as it is ready for the market.

Greenfield, Mass. CHARLES C. RUSSELL

RECHARGING PERMANENT MAGNETS

In the How and Why department of MACHINERY for December I note that A. B. has trouble in retaining magnetism in permanent magnets of magnetos. In the first place, the steel should be very hard, as this is an important feature of permanent magnets. As the magnetic flux is strong when the current is on, the current evidently flows in the proper direction; the trouble is elsewhere. I have magnetized permanent magnets with success by tapping them with a hammer while in the magnetic field. The sharp hammer blows seem to help the magnets take up the flux. The hammer should be of brass or other non-magnetic metal to prevent it from sticking to the magnetized steel. After the magnets are energized, they should be subjected to as few shocks or blows as possible, as this tends to weaken them.

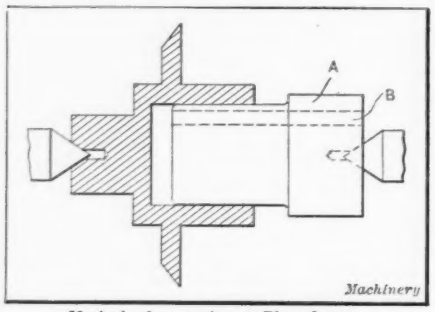
Youngstown, Ohio E. D. GAGNIER

SHOP AND DRAFTING-ROOM KINKS

INGENIOUS MEANS AND SHORT CUTS FOR SAVING LABOR AND MATERIALS

REMOVING A PLUG FROM A FINISHED PIECE

It sometimes happens that a finished piece with a regular center at one end and a central bore at the other must be held between centers on a lathe. Such a piece is shown in the accompanying illustration, where it will be seen that an auxiliary plug *A* has been driven into the bore to provide a bearing for one of the lathe centers. If it is necessary for this auxiliary plug to be a tight fit in the bore, it may be difficult to get the plug out again without spoiling the finish on the work. An easy way of doing this is to drill a small hole *B* of such a size that a piece of drill rod will be a slip fit in it. After filling the bore with oil, the piece of drill rod is inserted in the hole and then struck on the end with a hammer. This action is equivalent to that of a hydraulic ram and causes the plug to slip out of the bore in the work.

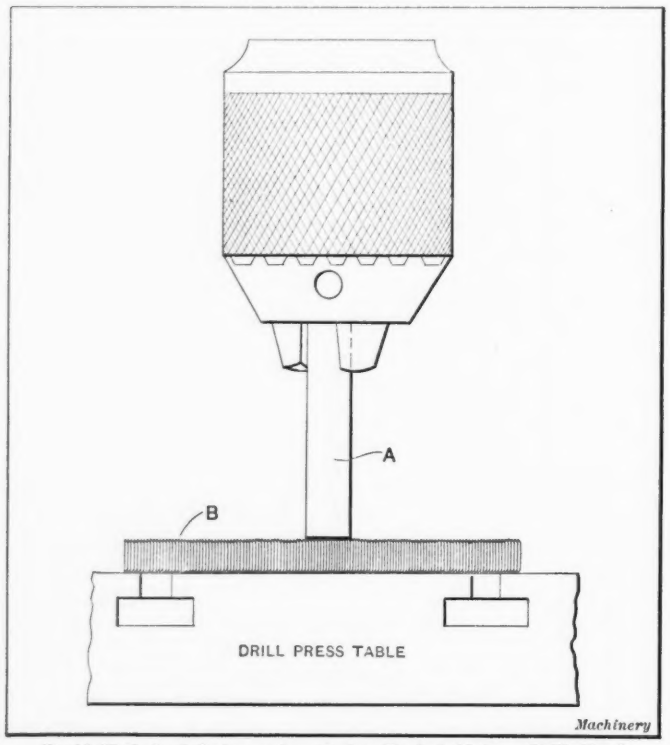


Method of removing a Plug from a Finished Piece

Detroit, Mich. HERMANN MUELLER

FACING STOCK IN A DRILL PRESS

The accompanying illustration shows a useful "kink" for facing off and finding the center of stock that can be chucked in a drill press. The stock to be faced is shown at *A*, which illustrates a piece of round stock held in the drill chuck and being fed against a flat file *B*. A few revolutions will be sufficient to locate the center of the stock. In facing pieces by this method, a bastard file can be used for roughing, after which the finish is produced with a smooth file.

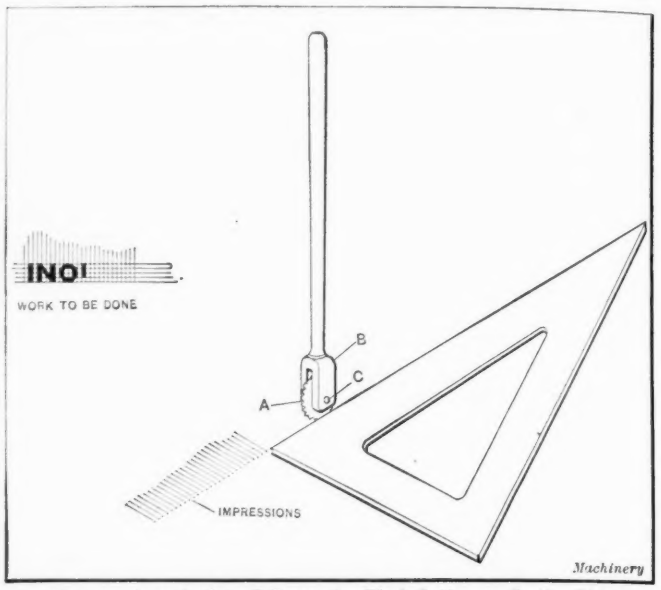


Rapid Method of facing and centering Stock held in a Drill Chuck

Corbin, Ky. J. A. JESSON

A HANDY DRAFTSMAN'S INSTRUMENT

It was necessary for a lot of neat block lettering to be made for titles of standardization sheets, etc. To do this well, accurate spacing is required. Such spacing, if done by the ordinary method of pricking it off from a scale, is very tedious as well as expensive, and it would pay any draftsman to make the simple little tool here shown. To do so, sharpen the teeth of a wheel from an old clockwork to the desired point and mount it in a handle *B* with a pin *C*. The wheel *A*, if run along a triangle, will impress dots with speed and accuracy. It will also be of aid in cross-sectioning.

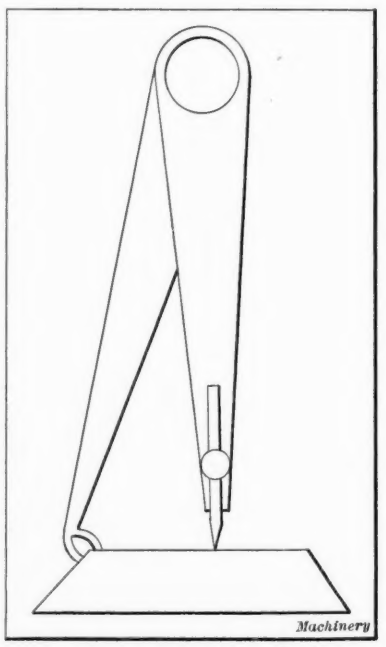


Instrument for laying off Spaces for Block Letters or Section Lines

East Lynn, Mass. R. F. POHLE

SPECIAL HERMAPHRODITE CALIPERS

The writer recently had to lay out some pieces with beveled sides and found that he could not use an ordinary pair of hermaphrodite calipers with only one hook on the leg. For this job, a special pair of hermaphrodite calipers, illustrated herewith, was designed. The illustration will be self-explanatory to any mechanic, but it may be mentioned that the size of the double hook is exaggerated in order to show it more clearly. There are probably many mechanics who have felt the need of such a tool from time to time. For the particular job for which these calipers were made, it would have been difficult to scribe a straight line for even a short distance with a tool of the ordinary design, as it would require a very steady hand to keep the calipers running on the beveled side of the work. The double hook did away with this difficulty entirely so that the laying out was a very simple matter.



Special Hermaphrodite Calipers for use on Beveled Work

Philadelphia, Pa. FRED HENKE

* * *

Don't forget that a drill with a short shank can be removed from the spindle, if a short piece of drill rod is dropped on the end of the shank through the spindle broach so the drift can strike it.

HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

MAKING TEMPLETS AND TOOLS FOR INVOLUTE GEAR CUTTERS

A. J. T.—I would like to see an article published in MACHINERY describing the process of generating or forming a templet and the tools for planing and backing off a one diameter pitch B. & S. involute gear tooth cutter. What I would like to know is how the templet is made so that it will be exactly alike on both sides and theoretically correct as to the radii of the curves and over-all dimensions; the kind of steel used and the process of making the tools and fly-cutters if any are used.

A.—The data on tooth shapes are regarded as a private matter by the manufacturers of so-called involute gear cutters. The method of making templet and formed cutters, however, is more or less common knowledge among first-class toolmakers. An article on the subject would be welcomed by the editorial department.

DRAW-BAR PULL OF TRACTORS—DRAFT OF PLOWS

B. E. M.—1. What percentage of the power of an internal combustion motor tractor is available at the draw-bar when working on soft soil? 2. What is the draft per unit of a gang plow?

A.—1. The draw-bar pull of tractors varies widely. The design of the driving wheels and the efficiency of the driving gear as well as the character of the ground on which the tractor is working must be taken into account. An average of the draw-bar pull of farm tractors working on soft soils probably would lie somewhere between 15 and 35 per cent of the power developed by the engine according to the experience of one tractor builder. Conditions may be so adverse, however, that the tractor is barely able to pull itself, when the pulling power, of course, will be practically nil. The design of the tractor wheels is an important consideration. The following data were furnished by C. H. Melvin of Deere & Co., Moline, Ill.: One tractor weighing 8000 pounds, with driving wheels 5½ feet diameter by 14 inches face, driven by a 40 horsepower, four-cylinder engine, developed 3000 pounds draw-bar pull under normal favorable traction conditions. Another tractor weighing 12,000 pounds and having four driving wheels 5 feet diameter by 12 inches face developed a draw-bar pull of 2950 pounds under exactly the same conditions. Apparently there is no rational basis as yet for fixing standard draw-bar pulls of different types of tractors.

2. The draft of plows varies greatly in different soils, as is indicated in the following table compiled from tests made of the draft of a single unit, 14-inch plow.

Corn stubble, 7 inches deep	300 to 350 pounds
Wheat stubble, 7 inches deep	350 to 400 "
Clover sod, 7 inches deep	350 to 450 "
Blue grass, 7 inches deep	500 to 600 "
June grass, 7 inches deep	500 to 600 "
Breaking prairie sod 3½ to 4½	700 to 800 "

A turf and stubble plow working under normal conditions to an average depth of 6 inches will require a draw-bar pull of 425 pounds, and the same plow will vary in draft in various conditions of soil from 250 pounds in light soils to 650 pounds under hard plowing conditions, and even more. In fact, 1050 to 1250 pounds pull is required in the black waxy Texas lands. M. Rumely Co., La Porte, Ind., states that under ordinary conditions the draft of a plow per square inch of cross-section in old ground is from 4 to 6 pounds; 2½ to 3 pounds in sandy ground and as high as 15 to 20 pounds in virgin gumbo sod. This company states that the draw-bar horsepower of a tractor ranges from 25 to 65 per cent of the indicated horsepower. Further information on the subject can be obtained from a book entitled "Power and the Plow."

TAPER TURNING WITH COMBINED FEEDS

A. S.—When taper turning is done with a vertical boring mill, by using the horizontal and vertical feeds in combination, how is the angular position of the tool-head determined? Suppose the surface is to be turned to an angle of 84 degrees (as shown in the illustration Fig. 1) and the tool feeds 8 inches in a horizontal direction while it feeds 5 inches vertically. How much should the tool-bar incline from the vertical?

A.—The method of determining the vertical position of a boring mill tool-head when turning tapers by using both feeds in combination, is as follows: If the horizontal feeding move-

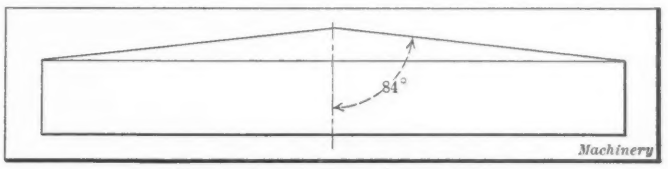


Fig. 1. Conical Shape to be turned

ment H (Fig. 2) is 8 inches and the vertical feeding movement V is 5 inches, obviously the surface will be turned to angle c, provided the head is vertical, but if inclined to some angle x, angle c will be diminished, and if the tool-bar is set over the right amount, the conical surface can be turned to an angle a equal to 6 degrees, thus giving an 84-degree angle as measured from the axis.

The first step in determining the angle x is to find angle b. The sine of angle $b = \dfrac{\sin a \times H}{V}$ in which H represents the rate of horizontal feed and V the vertical feed.

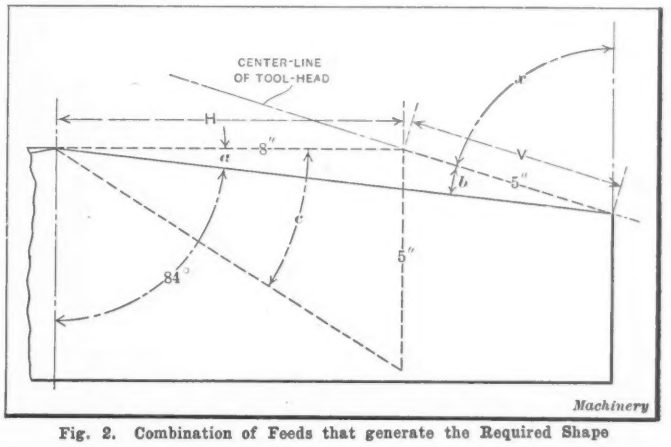


Fig. 2. Combination of Feeds that generate the Required Shape

The value of angle b is next found by referring to a table of sines. We now have angles b and a and by subtracting the sum of these angles from 90 degrees, the required angle x is obtained. To illustrate, the sine of 6 degrees or angle a, is 0.1045; hence $\sin b = \dfrac{0.1045 \times 8}{5} = 0.1672$.

By referring to a table of sines, we find that the angle corresponding to 0.1672 is 9 degrees 38 minutes, approximately; then angle $x = 90° - (6° + 9° 38') = 74° 22'$.

If the required angle a is greater than angle c, which is obtained when the tool-bar is in a vertical position, it would then be necessary to swing the lower end of the bar to the left, rather than to the right of a vertical plane.

* * *

The Ronay process for briquetting brass, bronze, aluminum and other metal chips, without the use of a binding material, was developed in Germany and is now protected in this country by U. S. patents. The process subjects every part of the material to heavy hydraulic pressure, so great that a comparatively solid briquette is produced. In order to produce the greatest possible solidity, it is necessary that the air be thoroughly expelled. The air cannot be expelled if the pressure is exerted in the mold from one direction only. It is necessary to exert pressure on the briquettes from the sides also. Briquettes produced by this process, in which all air is expelled, melt in the furnace with little or no more waste than pigs of new metal. The pressure employed approximates 30,000 pounds per square inch.

ANNUAL MEETING OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

The annual meeting of the American Society of Mechanical Engineers was held in New York City, December 2-5, the Engineering Bldg. being the headquarters. The papers presented covered a wide range of subjects, giving the program a scope and interest hardly before exceeded. They comprised boilers and their operation, cement, enameling, fire protection, gas measurement, gas power engineering, lineshaft bearings, machine tools, management, properties of steam, rope drive, steel railway cars, textiles with reference to mill engineering, and vacuum cleaning.

The president, Dr. W. F. M. Goss, read his presidential address, "Efficiency in Technical Education a Factor in the Development of Professional Ideals," Tuesday evening, after which a reception was given to the members and their friends. On Wednesday evening the Grashof medal, presented by the Verein deutscher Ingenieure to George Westinghouse, was conferred. Mr. Westinghouse was unable to be present because of illness, and the medal was transferred to the keeping of James Hartness the new president. An address illustrated by lantern views on Leonardo da Vinci, engineer and artist, was made Wednesday evening by John W. Lieb, Jr. The customary reunion took the form of a German dinner given Thursday evening. This dinner reproduced one of the menus served to the visiting engineers in Germany last summer. The dinner was held at the Hotel Astor and a brief account of the trip illustrated by lantern views was given by Worcester R. Warner, which was followed by dancing. The technical program comprised the following papers:

"Notes on the Further Operation of Large Boilers of the Detroit Edison Co.," by J. W. Parker.
"Task Setting for Firemen and Maintaining High Efficiency in Boiler Plants," by Walter N. Polakov.
"Properties of Steam," by R. C. H. Heck.
"Hoisting and Conveying," sub-committee report.
"Dynamic Braking for Coal and Ore-Handling Machinery," by Clark T. Henderson.
"Steel Under Frame Box Cars," by G. W. Rink.
"Steel Upper Frame Box Cars," by R. W. Burnett.
"Cotton Conveying Systems; their Safeguards against Fire," by H. A. Burnham.
"Specifications for Factory Timbers," by F. J. Hoxie.
"Textile Cost Accounting," by C. B. Annett and C. F. Cunningham.
"Efficiency of Rope Driving as a Means of Power Transmission," by E. H. Ahara.
"Comparative Tests of Three Types of Lineshaft Bearings," by Carl C. Thomas, E. R. Maurer and L. E. Kelso.
"Pitot Tubes for Gas Measurement," by W. C. Rowse.
"Tests of Vacuum Cleaning Systems," by J. R. McColl.
"Tests Upon the Transmission of Heat in Vacuum Evaporators," by E. W. Kerr.
"The Art of Enameling, or the Coating of Steel and Iron with Glass," by Raymond F. Nailler.
"Gears for Machine Tool Drives," by John Parker.
"Cast Iron for Machine Tool Parts," by Henry M. Wood.
"Standardizing Machinery," by Fred H. Colvin.
"A Record of Pressed Fits," by C. F. MacGill.
"A New Process for Cleaning Producer Gas," by H. F. Smith.
"The Present Status of Large Gas Engines in Europe," by Prof. P. Langer.
"Extinguishing Fires in Oils and Volatile Liquids," by Edward A. Barrier.
"The Fire Hazard in Turbo-Generators," by G. S. Lawler.
"Control of Automatic Sprinkler Valves," by Fred J. Miller.
"The Need of More Care in the Design and Construction of Elevated Tanks," by W. O. Teague.
"Fire Pumps," by Ezra E. Clark.

The entertainment included excursions to a number of power stations and manufacturing plants, among which were the tunnel construction plants of the Catskill Aqueduct, Waterside Station, P. R. R. and N. Y. C. Stations, Henry R. Worthington, Brooklyn Navy Yard, E. W. Bliss Co., Davis-Bournonville Co., etc.

The following officers were elected for the coming year: James Hartness, president; H. L. Gantt, E. B. Katte, E. E. Keller, H. G. Reist, vice-presidents; A. M. Dean, John Hunter, E. H. Whitlock, managers; W. H. Wiley, treasurer.

JAMES HARTNESS

James Hartness, the newly elected president of the American Society of Mechanical Engineers, is a son of John Williams Hartness and Ursilla Jackson Hartness; he was born in Schenectady, N. Y., 1861. The first twenty years of Mr. Hartness' life were spent in Cleveland, Ohio, where after passing through the public schools he entered practical work in machinery building plants. Following this early mechanical experience, three years were spent as foreman of a manufacturing plant in Winsted, Conn., and the next four years as foreman and inventor in a hardware manufacturing plant in Torrington, Conn.

James Hartness

In the fall of 1888 Mr. Hartness designed machinery for the Jones & Lamson Machine Co., in Springfield, Vt., and shortly afterward took an active part in the management of the company. He served successively as superintendent, manager and for the last dozen years as president. He is known in the machinery building industries as the inventor and manufacturer of various machines for metal turning, designed to take the place of the engine lathe. One of his first inventions in this line was the flat turret lathe which has been very successful, both from a mechanical and financial point of view. Another of Mr. Hartness' designs is the "Lo-swing" lathe built by the Fitchburg Machine Works, Fitchburg, Mass. Numerous patents have been taken out on other inventions, the total number of patents granted to Mr. Hartness being over eighty.

Mr. Hartness has been a consistent believer in the policy of specialization in manufacturing. When he went with the Jones & Lamson Machine Co., a large variety of machines was made, many of them being built to order. This practice was found to be unprofitable, and a change was effected in the direction of making fewer machines and manufacturing rather than building them. When the flat turret lathe was developed and put on the market, the time was ripe for specialization, and it was made the exclusive product of the company with very gratifying financial success. Mr. Hartness early recognized many of the basic principles of so-called scientific management and applied them in the design, manufacture and selling of machine tools.

A number of years ago Mr. Hartness became much interested in astronomy, and in 1910 he invented the turret equatorial telescope which had for its object the protection of the astronomer from the rigors of cold weather observation. This interesting astronomical apparatus was illustrated and described in a paper presented by Mr. Hartness before the American Society of Mechanical Engineers at the December, 1911, meeting. His accomplishment in this line is notable in that the object for which the design was made was attained without incurring the serious optical losses that had resulted from previous designs made for the same purpose.

Mr. Hartness has been a member of the American Society of Mechanical Engineers since 1891. He served as one of the

managers of the society from 1901 to 1912 and then as vice-president. He is a Fellow of the American Association for the Advancement of Science and a member of the British Institution of Mechanical Engineers, Verein deutscher Ingenieure, Astronomical and Astrophysical Society of America, London Astronomical Society, Royal Arts Society, Boston Chamber of Commerce and vice-president of the Western New England Chamber of Commerce, and an honorary degree of mechanical engineering was granted him by the University of Vermont in 1910. He is the author of "Machine Building for Profit" and "The Human Factor in Works Management." In both these books the author has shown his grasp of the psychological problems of industrialism. He is an advocate of specialization as a necessary means of making the best use of man's energies and adapting him to the world of today.

In addition to his interests in the Jones & Lamson Machine Co., Mr. Hartness is also interested in four other machinery building companies. He married Miss Lean Sanford Pond in 1885 and has two daughters: Mrs. Beardsley, wife of William H. Beardsley, M.D., of Springfield, Mass., and Mrs. Flanders, wife of Ralph E. Flanders of Springfield, Vt.

* * *

AWARD OF MEDALS BY THE AMERICAN MUSEUM OF SAFETY

An award of medals was made at the first annual dinner of the American Museum given to about four hundred guests at the Waldorf-Astoria Friday evening, December 12. These medals comprise the *Scientific American* medal, which is given for some safety or life-saving devices, invented within a recency of three years and exhibited in the museum's collections; the Dr. Louis Livingston Seaman medal, which is given for progress and achievement in hygiene and sanitation and the mitigation of occupational disease; the Rathenau medal, which is placed at the disposal of the Museum of Safety by Dr. Emil Rathenau, president of the Allgemeine Electricitaets Gesellschaft of Berlin; the Travelers Insurance Company medal, which is given to the American employer who has done the most for the protection of his work-people in limb and life; and the E. H. Harriman memorial medal which is given to the American railroad that has been most successful in protecting the lives and health of its employes and of the public.

The *Scientific American* medal, received by George M. Schroeder, secretary of the Welin Marine Equipment Co., was awarded his company for boat davits, lifeboats, rafts and life preservers. The Travelers Insurance medal, awarded the New York Telephone Co., was received by President U. N. Bethel and a special Travelers Insurance medal, awarded the Allgemeine Electricitaets Gesellschaft, by T. C. Martin. The Louis Livingston Seaman medal was received by President James A. Farrell for the U. S. Steel Corporation and the Rathenau medal by President G. E. Emmons for the General Electric Co. The E. H. Harriman memorial medal was awarded to the Southern Pacific Co., and received by Julius Kruttschmitt, chairman of the board of directors. Prof F. R. Hutton made the presentations.

Following the presentations, Dr. William H. Tolman briefly reviewed some of the safety and welfare work being done in the United States and in Europe, especially Germany.

* * *

The Pennsylvania Railroad has introduced an innovation in dining car service. A new steel lunch counter car was put into service between New York and Philadelphia, December 1. The new car is eighty feet long and the exterior appearance is the same as a Pennsylvania R. R. all-steel passenger car. The interior is quite different from the ordinary dining car; instead of tables, there is one long table extending over half the length of the car. Facing this counter are revolving chairs fastened to the floor, and twenty-one people can be seated at once. The pantry and kitchen are at one end of the counter. The convenience of a lunch counter car to travelers between New York and Philadelphia should make it popular with the traveling public.

EXHIBITION OF AUTOGENOUS CUTTING AND WELDING

On the afternoon of December 4, about one hundred and fifty members and guests in attendance at the annual meeting of the American Society of Mechanical Engineers, made an inspection visit to the plant of the Davis-Bournonville Co., Jersey City, N. J., where arrangements had been made to give a demonstration of autogenous cutting and welding equipments. The Davis-Bournonville plant is divided into two general sections, one of which is devoted to building cutting and welding equipments and the other to job work in welding. The exhibits in the factory consisted of mechanically-guided cutting and welding torches, all of which were shown in operation. In the welding shop, various classes of welding—both repair work and applications of the oxy-acetylene process of welding in building new equipment—were shown. In addition, the practice followed in the generation of acetylene was demonstrated, and in the yard outside the factory several exhibitions of cutting heavy metal with both the oxy-acetylene and oxy-hydrogen flames were demonstrated. All of the different exhibits were numbered and placards were provided showing what class of work was being handled in each case. This enabled the visitors to see at a glance what work they were most interested in and to study the demonstration of the work in its details.

In the exhibition of mechanically-operated welding and cutting torches, the following machines were shown: The No. 1 and No. 2 "oxygraphs" were shown cutting out various shaped pieces. The "railagraph" and the "holograph" were shown cutting off rails and cutting the holes in the webs of rails for bolting the joints together. An interesting application of the "radiagraph" consisted of cutting rings from one-inch plate to form flanges for power plant piping. Where this method is used, the flanges are cut out to fit the ends of plain pipe and are then welded in place. The automatic barrel welding machine was also shown in operation for the first time.

In the welding shop, various classes of welding work were being done. As examples of repair work, it may be mentioned that metal was added to gear-wheels at points where teeth had been broken off, in order to provide for cutting new teeth. A cracked engine cylinder and broken flue-bridges in a boiler were also welded. An interesting demonstration of the application of the oxy-actylene torch in the case of welding products in course of manufacture consisted in the production of expansion bends for use in power plants. The steel plates from which these bends are made are blanked and formed so that they fit together with a reasonable degree of accuracy. Consecutive plates are put in place so that the edges come fairly close together; the welding torch is then used to melt the metal so that it fuses together forming a tight joint. Demonstrations of the practice followed in welding aluminum, brass, iron, steel and other metals were conducted.

Among the more spectacular exhibitions of heavy cutting that were made in the yard outside the factory, the following may be mentioned: The oxy-hydrogen flame was used in cutting a slab of armor plate 16 inches thick. This slab was 12 inches wide, and a cut was made through the piece in three minutes and thirty seconds. Another interesting example of cutting was shown in connection with the emergency equipment which has been developed for use by municipal fire departments in cutting away steel bars that may impede their progress. The oxy-acetylene cutting torch for this purpose enabled three one-inch steel bars to be cut from a grillwork in a few seconds, making a space large enough for a man to pass through. Each bar had to be cut twice, making six cuts in all.

Particular credit is due to the Davis-Bournonville Co. for the efficient way in which the exhibition was handled. By having the general exhibits separated and each one continually in operation, the visiting engineers were able to see each exhibit and get a good idea of the work that was being shown. This would have been impossible if a large crowd had been gathered around each individual machine at one time when it was in operation.

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW DESIGNS AND IMPROVEMENTS
IN AMERICAN METAL-WORKING MACHINERY AND TOOLS

LODGE & SHIPLEY UNIVERSAL TOOL-ROOM LATHE

The new model universal tool-room lathe built by the Lodge & Shipley Machine Tool Co., Cincinnati, Ohio, which is illustrated in Fig. 1, is made in a 16-inch nominal size but actually swings 18½ inches. To meet the requirements of various users, different types of headstocks can be furnished, *viz.*, 4-step and 5-step cone, single back-geared, 3-step cone,

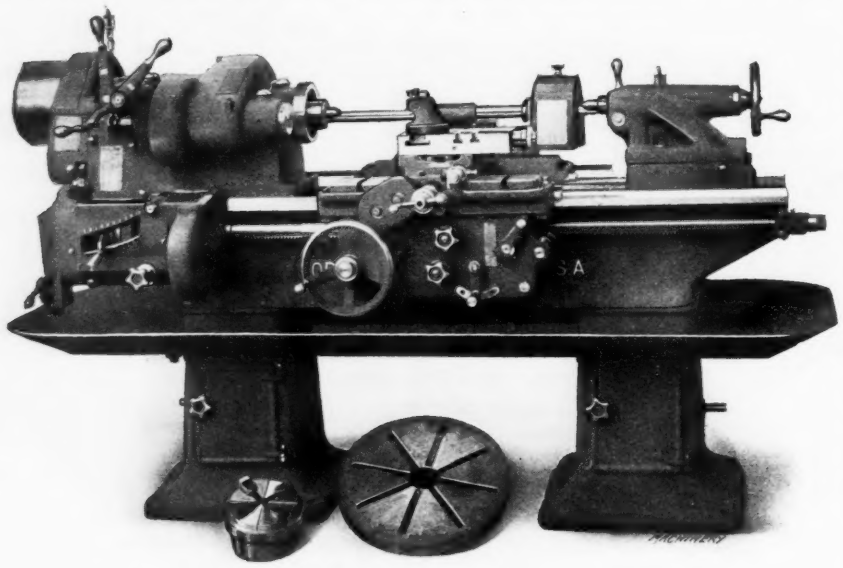


Fig. 1. Lodge & Shipley Universal Tool-room Lathe with "Selective Head"

double back-geared and "selective head" for single-pulley belt or motor drive. As the universal tool-room lathe is designed especially for tool-room work, it has certain refinements and attachments not required in lathes for manufacturing purposes. The unit system of construction is employed throughout, so that the application or omission of various attachments which can be furnished, will in no way affect the other parts. All parts are made interchangeable so that attachments ordered subsequently can readily be applied by the customer.

The 16-inch by 6-foot "selective head" type is shown in Fig. 1. This lathe has full equipment comprising a pan, universal taper attachment, universal relieving attachment, translating gears for cutting metric threads in addition to English threads, draw-in chuck with collets, and step chuck with closer. Fig. 2 shows a 16-inch by 6-foot, 4-step cone-head- universal tool-room lathe without additional appliances.

Headstock and Tailstock Construction

As the selective head was described in the July, 1913, number of MACHINERY, it is sufficient merely to mention that when driven by a constant-speed belt or motor, the selective head gives twelve changes of spindle speeds obtainable through conveniently located shifting levers, and that this head derives its name from the selective type transmission used in the gear box where there are chrome-nickel steel heat-treated gears mounted on chrome-nickel steel shafts running in ball bearings. The double nose for the spindle (as formerly described in conjunction with the selective head) is used in both the selective- and the cone-head lathes. It provides a pilot for centering the chuck or faceplate and a large diameter of shoulder against which the plate is screwed.

As illustrated in Fig. 2, the main housing of the cone head is carried up slightly above the center line of the spindle. This makes a very rigid construction and ties the front and rear spindle bearings securely to each other and to the head. In each of the different styles of heads, the back-gearing is designed to give uniform progression over the entire range of speeds. On the 3-step cone head the double back-gear is moved lengthwise by means of a lever conveniently located at the top of the headstock cover. In the selective head, the back-gearing is located at the front of the head and the face gear pinion may be withdrawn from mesh. The back-gear sleeve and pinion are both cut from a single steel forging.

The spindle bearings are of special white metal, interchangeable and replaceable, fitted and held into the headstock by screws. These bearings are faced and turned in halves to exact standard size, and the screw holes are drilled to jig. The end thrust of the spindle is taken against the rear housing by alternate hardened steel and bronze washers. Oil wells are provided over the spindle and back-gear bearings, and a wick oiling system delivers the proper quantity of oil by capillary attraction. All bearings in the quick change gear mechanism and apron are reached by suitable oil tubes.

The tailstock has a long bearing on the bed and is designed to allow the compound rest to be set at 90 degrees when using the tool on small diameters. Set-over screws are provided, and a hardened scale is secured to the lower side. Plug clamps lock the spindle without throwing it out of line. The spindle is made of tool steel, graduated lengthwise on top for quick reference, and has a long traverse.

The bed is of box section, wide and deep, and the legs are

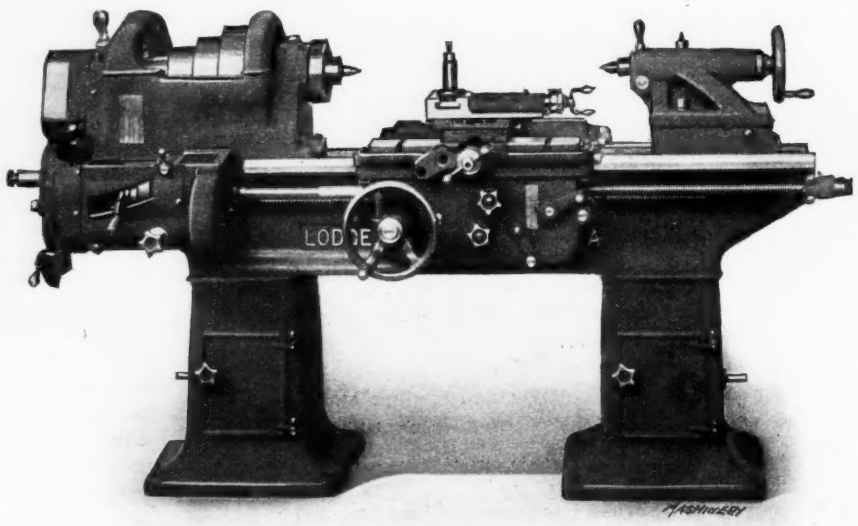


Fig. 2. Lodge & Shipley Tool-room Lathe with Cone-head Drive

set in from the ends. The ways are chilled, which greatly increases the life in alignment. The girders are as wide as the space between them. The six-foot bed has three girders, all of which are of the inverted U type. A planed pad is located directly under the headstock and this pad receives the quick change gear box which is tongued and bolted to it. A coarse-pitch steel rack is bolted to the bed directly back of the lead-screw.

Carriage and Quick-return Mechanism

The carriage, a top view of which is shown in Fig. 3, has an unusually long bearing on the outside shears. It is gibbed at the front, back, and inside. The bridge has a supplementary bearing on the inside front shear of the bed, for resisting the pressure of the cut and absorbing the vibration from the cutting tool. An oil trough is cast entirely around the carriage, and shear wipers are provided for the bearing surfaces. The cross-feed screw has a large self-locking micrometer dial graduated to thousandths of an inch. All carriages are planed and drilled to receive either style of taper attachment, and also to receive the relieving attachment, and no additional fitting is required when applying these parts.

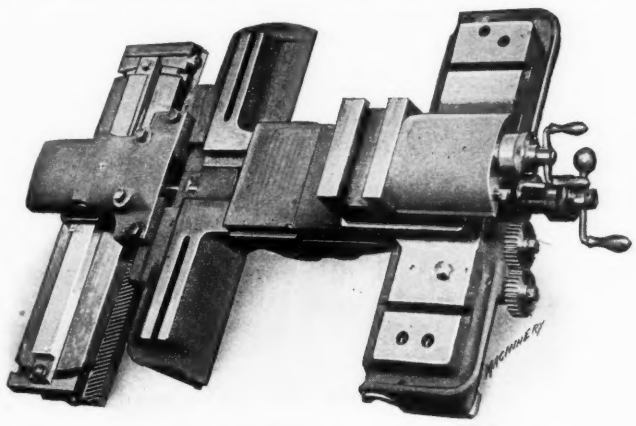


Fig. 3. Top View of Carriage with Universal Taper Attachment

The compound-rest top slide is provided with a large self-locking micrometer dial, graduated to thousandths. It is designed so that the extreme width of the swivel rests directly upon the lower slide, thus avoiding overhang of the top slide. The apron is of the double-plate type and is provided with all steel feed gearing throughout. The handwheel for imparting hand motion to the apron can be disengaged from the stem while chasing. All shafts have unusually long bearings and oil receptacles are provided to properly distribute the oil to all bearings. The half-nuts interlock with the friction feed mechanism. The apron is tongued and bolted to the carriage and the pinion engaging the rack on the bed is made of high-carbon steel and hardened. The lead-screw is set well up under the front carriage V to avoid overhang.

An entirely new quick return of the carriage for screw cutting is incorporated in the apron. The reverse is by friction and is controlled by the movement of the same lever which opens the half-nuts. By raising the half-nut lever, thus disengaging the half-nuts, the carriage stops. If the lever is raised slightly higher, the quick return mechanism is engaged, and the carriage returns four times as fast as the speed at which the thread is being chased.

Chasing Dial—Chasing Stop

A new design of chasing dial is provided which has a hardened notched disk mounted upon the shaft which is secured to a worm-wheel engaging the lead-screw threads. This notched disk has longitudinal movement and any selected index may be engaged with the stop dog which prevents the half-nuts from becoming engaged, until the proper notch in the disk is presented to the dog. This preserves the accuracy of the lead-screw on account of preventing the half-nuts from clamping on the tops of the threads, and it is also valuable in that the operator need not watch a dial.

Fig. 4 illustrates the automatic chasing stop which is attached to the dovetail of the carriage by a clamping screw and is directly connected to the lower slide of the compound rest. Its function is to form a dead stop for succeeding cuts over the thread. The rate of advancement or depth of cut can be adjusted to thousandths of an inch by knurled screws, and this cut may be varied from 0.002 inch to 0.010 inch of depth. The setting for the depth of cut is accomplished by withdrawing the cutting tool from the work. In using this device the operator need not watch the micrometer dial, but can chase the thread to the proper depth, the rest at all times coming directly against the dead stop. This chasing stop prevents breaking the point of the tool and with the quick return reduces chasing to a very simple operation.

Quick-change Gears

The quick change screw cutting and feeding attachment is bolted to a pad on the front of the bed. This attachment has two shaft centers, one for the lead-screw, and another for the cone of steel gears. The sliding tumbler is supported in a slide independent of the shaft bearings, and this slide is arranged close to the handle which moves the sliding tumbler within the slot, thus avoiding overhang of the handle and preventing binding and cramping when setting. Both shafts of the gear box extend through the left end of the box, and the change gear may be applied to either of these shafts. Power is transmitted from the feed gear on the end of the spindle, through a reverse plate to the stud in the headstock, then through a quadrant mounted on the end of the gear box which quadrant gives three changes. The gear box itself gives thirty changes, so with the quadrant, ninety changes are provided in the regular quick change gear mechanism. The housing carrying the sliding tumbler is locked into position before the intermediate gear can be meshed with the selected gear of the cone. All the shafts are short and the drive is direct. The index is simple and is attached to the top of the box where it can be seen readily by the operator. The machine may be ordered with the plain English threading index, and the metric attachment can be subsequently supplied without any additional fitting.

Equipment for Metric Threads

With the metric index it is necessary to make the cone of gears the driver, whereas in the English index the cone of gears is the driven member. When supplying the machine with the metric attachment, it is only necessary to add a gear cover, into which is mounted the translating gears. This gear cover is machined and made a duplicate of a plate which is secured to the gear box when the metric compounding gears are not supplied. When the gear box is arranged for metric pitches it is possible to cut either metric or English threads by simply turning a knob attached to the bottom of the box. By turning this knob to the left the metric pitches are obtained, and to the right, the English. It is also

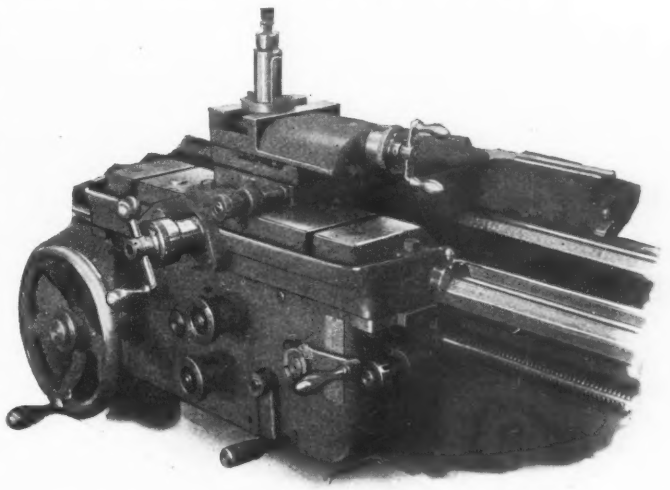


Fig. 4. Detail View of Carriage showing Chasing Dial and Stop

necessary to place the driving gear at the end of the gear box on the proper shaft; the upper shaft for the English and the lower for the metric.

Plain and Universal Taper Attachments

The taper attachment requires no planed strip on the back of the bed, and therefore a special bed is not required, and the taper attachment can readily be applied to the machine at any time. All carriages are drilled to receive it. The bracket carrying the swivel bar is bolted to travel with the carriage so that at whatever part of the carriage the taper attachment may be, it can be engaged instantly. The taper attachment slide is provided with an extension which may be connected on either side, and this extension engages the

arm which clamps it to the bed and holds it stationary when the carriage is feeding. The taper attachment swivel is a steel straightedge. A gibbed shoe slides upon it, and this is secured to a slide which confines the cross-feed screw to it. The cross-feed screw telescopes through the cross-feed pinion on the front side of the carriage; thus the taper attachment may be used with a plain rest or with a relieving attachment, and the depth of cut set by the cross-feed screw. The hardened steel straightedge can be set to graduations in inches per foot, and a micrometer adjustment is provided to give extreme accuracy in setting. A nicely graduated steel scale with a compensating pointer gives accurate reading to the swivel bar.

In addition to the parts just described for a plain taper attachment, the universal taper attachment has a power traversing mechanism which provides various rates of travel.

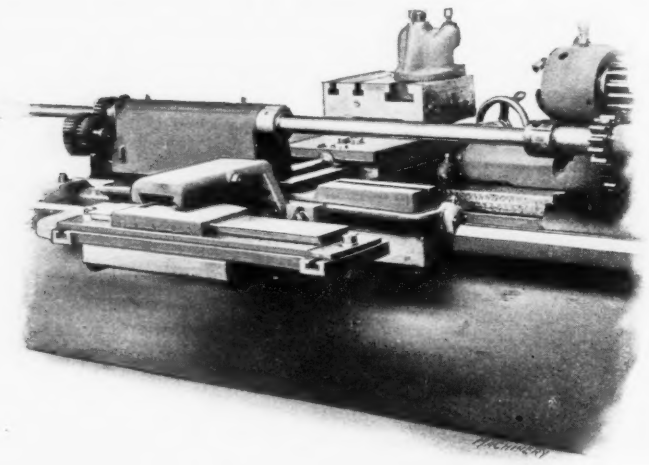


Fig. 5. Universal Relieving Attachment

Fig. 3 shows the universal taper attachment fitted to carriage. A cover plate which protects the taper attachment rack, and a cover for the gears on the front of the apron, are purposely omitted to give a clearer idea of the construction. The mechanism for giving power traverse to the swivel bar of the universal taper attachment is controlled by a shaft extending through the bridge of the carriage and operated by change gears at the front, driven direct from the apron feed train. Thus, when the universal traversing mechanism is employed, the forces necessary to produce the taper are all contained within the carriage, and all side pull is eliminated.

The plain taper attachment is satisfactory for tapers not exceeding 4½ inches per foot, but on very abrupt tapers it is impossible to feed the tool against such steep angles, and to accommodate work of this character the independent driving mechanism for the taper attachment slide has been provided. Since the slide can be fed at various speeds, it is capable of turning much longer tapers than with the plain taper attachment; in other words, if the slide feeds one-third as fast as the carriage, the carriage will travel three feet while the slide is traveling one foot, and *vice versa*. The complete range of the universal taper attachment covers tapers from 1½ inch per foot and 54 inches long, up to 13½ inches per foot and 6 inches long.

Universal Relieving Attachment

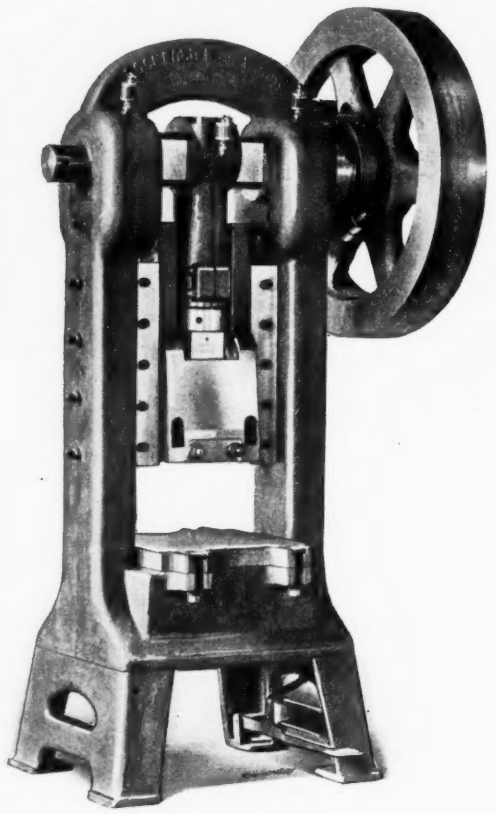
The relieving attachment illustrated in Fig. 5 is designed to produce radial, angular, end, or inside reliefs. It is never necessary to go behind the machine to make adjustment. Power is transmitted from the splined shaft at the back of the bed, through a sleeve and change gears, to a shaft below and parallel with the driving shaft. This lower shaft in the housing transmits its power through hardened spiral gears to the cam-shaft which takes its bearing in the cross-slide. This cam-shaft engages a roller mounted in a plunger. The plunger engages a bell-crank which is mounted in the top slide of the relieving attachment. The abutting portion of this bell-crank is made adjustable by an adjusting screw, and by removing the top cover this screw can be adjusted for various depths of relief from zero to ⅛ inch movement of the slide. Since the power for operating the relieving slide is supplied directly through the swivel center, the swivel itself may be set at any angle without affecting the movement of the slide; thus it is possible to relieve at any angle, inside or outside, or on the face of a piece of work. The cam-shaft is placed below the surface of the bridge so that the full swing over the bridge is obtained for relieving.

Chucks and Collets

The draw-in chuck is mounted directly on the nose of the spindle. No draw tube passes through the spindle, which makes it possible for the draw-in collet to receive stock as large in diameter as the size of the hole through the spindle. Collets may be furnished for diameters from ⅛ inch to 1 5/16 inch inclusive. The collets are tightened and released by a small key wrench, which makes it unnecessary to hold the driving belt when tightening and releasing the chuck. A step chuck with adjustable jaws and closer is made to apply to the regular draw-in chuck body and is very desirable when a finished piece must be true; it is also useful for facing thin pieces of large diameter.

ROCKFORD STRAIGHT-SIDE POWER PRESSES

The No. 8 size of a line of straight-side power presses which has been placed on the market by the Rockford Iron Works, Rockford, Ill., is shown in the accompanying illustration. Like the inclinable type of presses built by this company, the straight-side machines are built to meet the requirements of modern manufacturing work. The frames are of massive construction, the shafts of ample proportion, and the slides are of exceptional length and width and supported in gibs for nearly their entire length. A special feature is the construction of the main bearings which are so designed that they can be adjusted by means of a sliding wedge.

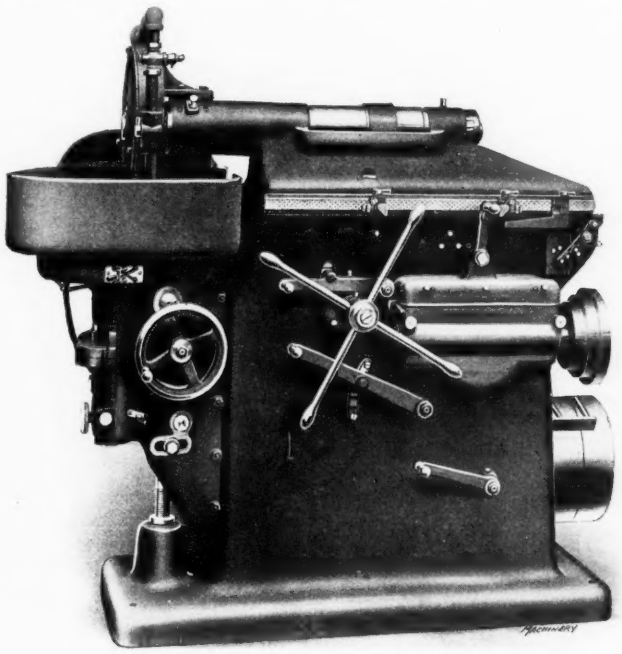


No. 8 Size of Rockford Straight-side Power Press

The straight-sided presses are especially adapted for such work as trimming drop-forgings and for heavy punching, piercing, stamping or forming operations. They are made in three standard sizes which weigh 5000, 7000 and 10,000 pounds, respectively. The 10,000-pound machine is shown in the illustration; this machine has a capacity for pressures up to 100 tons. The weight of the flywheel is 2000 pounds, the diameter of the shaft 4¾ inches, and the width of the main bearings 9 inches.

HEALD ROTARY SURFACE GRINDER

The 16-inch rotary type of surface grinding machine illustrated herewith is a recent product of the Heald Machine Co., 20 New Bond St., Worcester, Mass. This machine is intended for grinding flat surfaces on a great variety of work that can be rotated within its capacity, and combines accuracy with a high rate of production. The frame is of massive construc-



Heald 16-inch Rotary Surface Grinder

tion with the metal distributed in a way that insures great rigidity. The bearings are of ample proportions; all shafts are carefully ground to accurate dimensions, and the ways of the machine have broad wearing surfaces to maintain correct alignment. The grinder is driven by a single belt direct from the lineshaft, no countershaft being required.

The grinding is done by the periphery of a wheel 14 inches in diameter by 1¼ inch face. This method of using the wheel is claimed to be the most satisfactory where a high degree of accuracy and perfection of finish is necessary. When this practice is followed, feed lines and radial scratches on the work are practically eliminated. The wheel spindle is hardened and ground and runs in phosphor-bronze bearings that are provided with efficient means of lubrication and adjustment for wear. The belt pull is downward and acts in conjunction with the weight of the wheel slide to prevent the wheel from lifting under heavy cuts. This is an important factor in the high rate of production and accuracy of finish attained on this machine.

Either a 12- or a 16-inch magnetic chuck constitutes part of the standard equipment of this grinder, but other types of chucks or work-holding fixtures can be used when so desired. The 12-inch chuck has a capacity for rings up to 11 inches in diameter and disks up to 12 inches in diameter; the 16-inch chuck has a capacity for rings up to 15 inches in diameter and disks up to 16 inches in diameter. The vertical adjustment of the chuck on the grinder is 7 inches. Angular adjustment for the chuck and work spindle are also provided for use in grinding concave or convex surfaces. This adjustment is also useful in correcting slight errors of alignment which may develop after the machine has been placed in service.

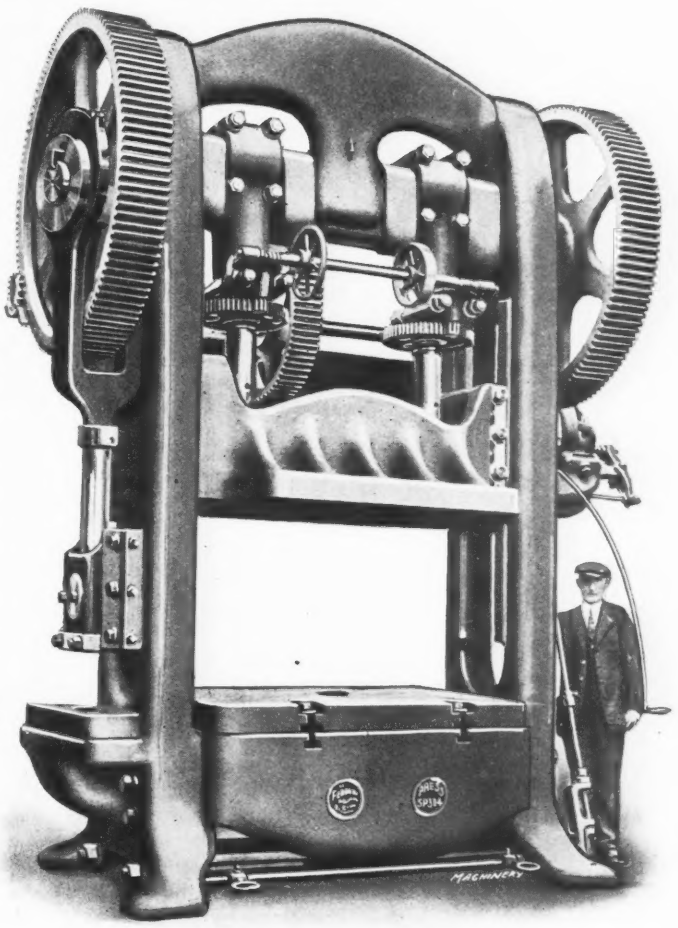
Six changes of chuck speed are available, either of which may be instantly obtained without stopping the rotation of the chuck. The work is fed to the wheel by elevating the chuck. This is accomplished by means of a screw and handwheel which is provided with a graduated dial reading to 0.001 inch. The machine may also be provided with vertical power feed as a special equipment. The wheel is fed across the work by either hand or power, the hand feed being especially satisfactory for use on small work. Three power feeds are available in connection with each work speed and each power feed is automatically reversed.

The grinder is equipped with a pump, tank and water guards for use in wet grinding. The pump furnishes a liberal supply of water which is under absolute control of the operator. The guards are designed in such a way that they prevent water from being splashed onto the operator or thrown on the floor, and also protect the bearings from being damaged by water. Centralized control is a strong feature of this machine, every lever and wheel being located within easy reach of the operator without requiring him to move from his position at the front of the machine. The maximum diameter of the surface that can be ground on this machine is 16 inches, but the machine will swing 22 inches so that it is possible to handle parts that have projecting members extending out beyond the actual surface that is to be finished. The thickness of the work that can be handled is 4½ inches with the size of wheel that is ordinarily used; by using a smaller wheel, however, work as thick as 7 inches can be ground.

FERRACUTE SINGLE-ACTION PRESS

The Ferracute Machine Co., Bridgeton, N. J., is now building a new line of double-crank, single-action presses. These machines are made in various widths between the columns, but all of them exert the same pressure—300 tons. One of this line of presses is shown in the accompanying illustration, this particular machine having a distance of 76 inches between the columns.

These presses are equipped with side punches which make them virtually two presses combined in a single machine.



Ferracute Double-crank, Single-action Press with Capacity of 300 Tons

The side press is found useful for a variety of purposes such as shearing off stock before or after it has been worked on by the main press or for punching holes and slots. The shaft is a high-carbon steel forging with a diameter of 8½ inches at the journals and 10 inches at the cranks. The standard stroke of these machines is 3 inches, but the presses are de-

signed for any stroke up to 24 inches; the illustration shows a press which has the maximum stroke. The adjustment of the ram is 4 inches and the height from the bed to the ram, with the ram at the top of its stroke and adjustment, is 24 inches. The ram is adjusted by means of a worm-shaft connected by gearing to the pitmans, the action on which is simultaneous. The worm-shaft may be revolved by hand, but a pulley is also provided to enable the adjustment to be made by the motor.

These presses are equipped with a combination friction clutch and brake by means of which the machines may be started or stopped at any point of the stroke. The flywheel has a diameter of 40 inches, a face width of 12 inches, and weighs 1800 pounds. The twin gears are 76 2/3 inches in diameter by 11 inches face width, the ratio of the gearing being 40 to 1. The depth of the bed from front to back is 50 inches, and there is an oblong hole in the bed 58 by 36 inches in size. The bolster is 5½ inches thick. The press shown in the illustration weighs about 72,000 pounds.

GARVIN VERTICAL SPINDLE MILLING MACHINE

The vertical milling machine which the Garvin Machine Co., Spring and Varick Sts., New York City, has recently added to its line possesses a number of features that increase its productive capacity. Both the table and cross-slide are provided with fast feed in either direction, which is controlled by automatic trips in the same way as the regular feeds. The

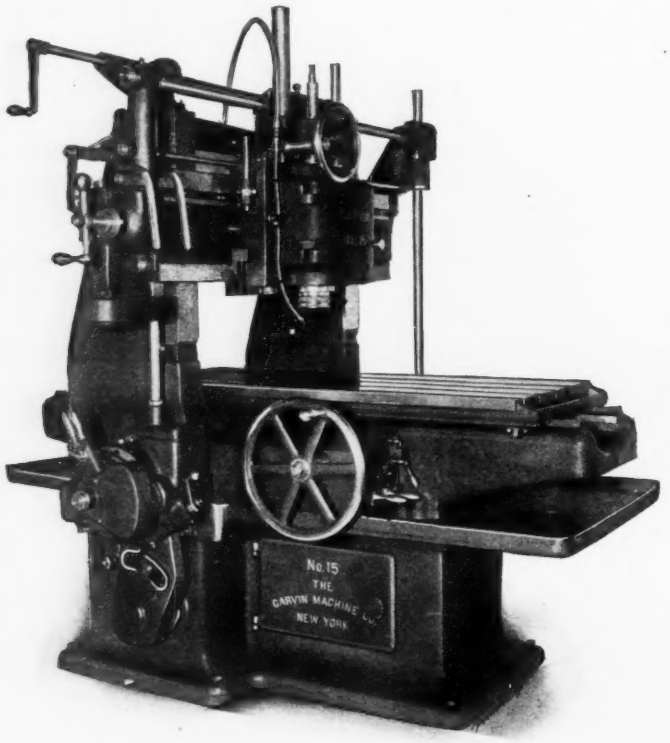


Fig. 1. Garvin No. 15 Vertical Spindle Milling Machine

drive is self-contained, power being transmitted through a cone pulley supported on a bracket secured to the base of the machine. This design lends itself readily to the application of individual electric motor drive, a silent chain being used to connect the motor to the cone pulley shaft, as shown in Fig. 2. Power is taken from the cone pulley shaft through bevel and spur gears connecting with the upper ends of the spindle and back shaft. By shifting one gear, the spindle may be driven direct at high speed or through the back-gears at slow speeds, and in each case the direction of rotation is the same. The spindle has a threaded nose 3¼ inches in diameter to take a No. 24 B. & S. cutter; and sufficient power is provided by the machine to drive a cutter 12 inches in diameter.

The table movement is obtained through a Sellers drive which is controlled by a pilot wheel. Both the table and cross-slide are equipped with double feed boxes, giving either the regular or the fast feed at the will of the operator. These feeds are thrown in by separate handles and controlled by dogs on the table and cross-slide in the ordinary way. Two styles of dogs are provided on both the table and the cross-slide. One set of these dogs provides for tripping and coming up against a solid stop, while the other set are buttons that trip the feed but permit of passing over. The fast and the regular feeds are in the same direction, so that the arrangement permits of making quick jumps over intervening spaces be-

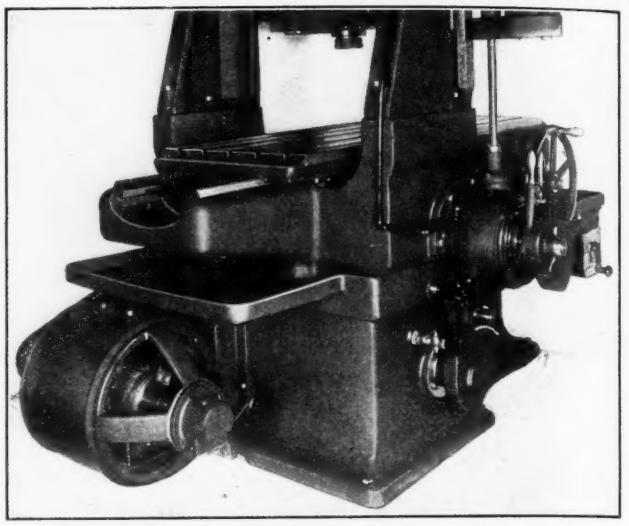


Fig. 2. Motor Drive through Silent Chain applied to Garvin Milling Machine

tween cuts. An interlocking mechanism prevents throwing in both the fast and the regular feed at the same time. One turn of the change feed handle throws the gearing in the feed box out of action, and when this is done another handle on the box may be operated to traverse the table and cross-slide rapidly back or forth by power. The second handle is interlocked with the feed-box to prevent the possibility of accidents.

STOW PORTABLE ELECTRIC TOOLS

The accompanying illustrations show a toolpost grinder and a breast drill which constitute recent additions to the line of portable electric tools made by the Stow Mfg. Co., of Binghamton, N. Y. The toolpost grinder is particularly adapted for grinding lathe centers, dies, cutters and a variety of other classes of work, and it handles both internal and surface grinding. It will be seen from Fig. 1 that a flexible cord and

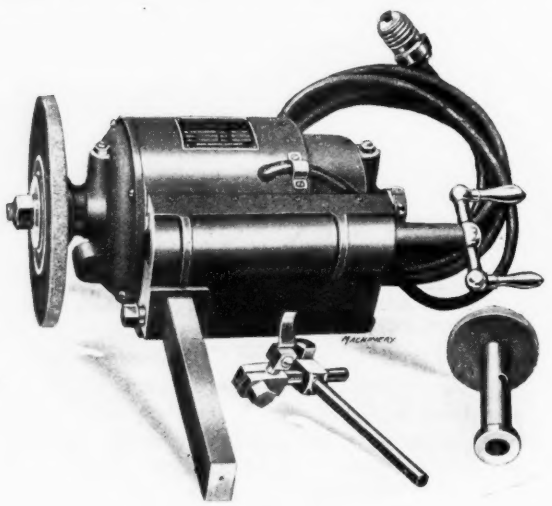


Fig. 1. Stow Electric-driven Toolpost Grinder

plug are used to supply current to the motor, the plug being connected to an ordinary lamp socket. The motor for this grinder is made for 110- or 220-volt, 60-cycle alternating current; or for 110- or 220-volt direct current. The wheel used for external work is 6 inches in diameter by ⅜ inch face and the attachment for internal grinding is shown beside the motor.

Fig. 2 shows this company's new breast drill which has a capacity for drills up to ½ inch. This tool is equipped with

either a Jacobs or Pratt chuck for straight shank drills. Like the toolpost grinder, the drill motor is provided with a flexible cord for connection with a lamp socket. There is a switch in the handle for controlling the motor. The motor is for use on 110- or 220-volt, 60-cycle alternating current circuits; or for

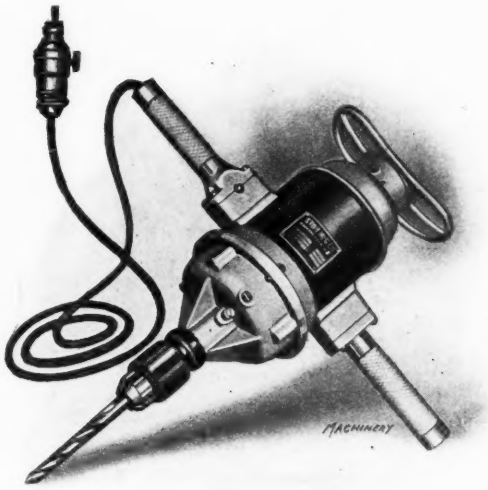


Fig. 2. Stow Portable Electric Breast Drill

110- or 220-volt direct-current circuits. Particular attention has been paid to having all parts of the drill carefully balanced so that it is convenient to handle.

CINCINNATI EIGHTY-FOUR INCH PLANER

The accompanying illustrations show an 84-inch planer which has been added to the line of the Cincinnati Planer Co., Cincinnati, Ohio. In designing this machine particular attention has been paid to the means for obtaining rapid manipulation of the heads; all of the control levers are also conveniently placed for the operator, so that this planer is just as handy to run as a smaller machine. Rapid power traverse in both directions is provided for all the heads, and all movements are independent of each other and can be operated whether the table is moving or not. The motor at the top of the machine is used for driving the rapid power traverse and feed to the heads, and for elevating or lowering the cross-rail. The motor pinion engages a large gear on the horizontal rapid traverse shaft from which the pinion that drives the feed clutch receives its power; the latter is shown at the right-hand end of the shaft. Near the center of the horizontal shaft there is a gear that meshes with a pinion on the gearcase of the elevating mechanism, through which power is transmitted for moving the cross-rail. A lever from this gearcase passes to the left-hand side of the machine and operates the clutches for raising or lowering the cross-rail.

The power feed to the heads receives its power from the driving clutch which has a bell-crank and link motion to the bevel gear on the horizontal shaft. This bevel gear meshes with a gear on the vertical shaft which drives the trigger gears on the end of the rail and side heads through spur gears. The driving clutch is tripped by a rod that receives its motion from the tumbler and dogs on the side of the table and bed. The feed is varied by graduated heads which indicate the exact amount of feed at all times, thereby eliminating guesswork. The rapid power traverse receives its power from a second vertical shaft on the side of the housing, the arrangement being similar to that employed for the feed. The small handles seen at the end of the rail and side heads operate the rapid power traverse and feed. Turning these handles to the left engages the rapid power traverse, and turning them to the right engages the regular feed. It is impossible to engage both movements at the same time. The handle at the bottom of the rail is used for reversing the direction of the rapid power traverse. The gearing is contained in the case at the end of the rail, and the operator can make any desired change without moving from his position.

All the heads are taper gibbed and the clapper box is held by a heavy clamp and three screws. The housings are of massive box construction, tongued and doweled to the sides of the bed and fastened at the top by an arch. The cross-rail is secured to the housings by inside and outside clamps which give great rigidity. The table is also of box form and is heavily ribbed to give the required stiffness. The ways are oiled by forced lubrication provided by a pump at the back of the housing. The bed is of the four-wall type and exceptional care has been taken with the bracing. It is bored to receive the driving shaft boxes, which are of large diameter and provided with oil chambers of ample size. All driving gears are of steel and the pinions and table racks are cut from steel forgings. Fig. 1 shows one of these planers with a 34-foot table; and Fig. 2 shows the arrangement of the reversible motor drive, in which the motor is connected direct to

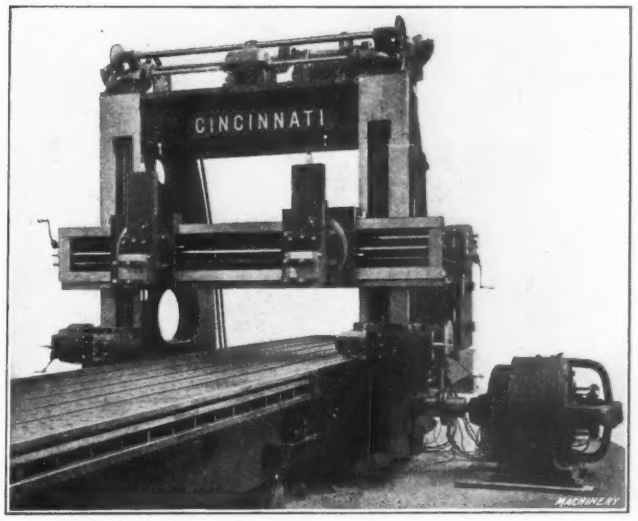


Fig. 2. Arrangement of the Reversible Electric Motor Drive

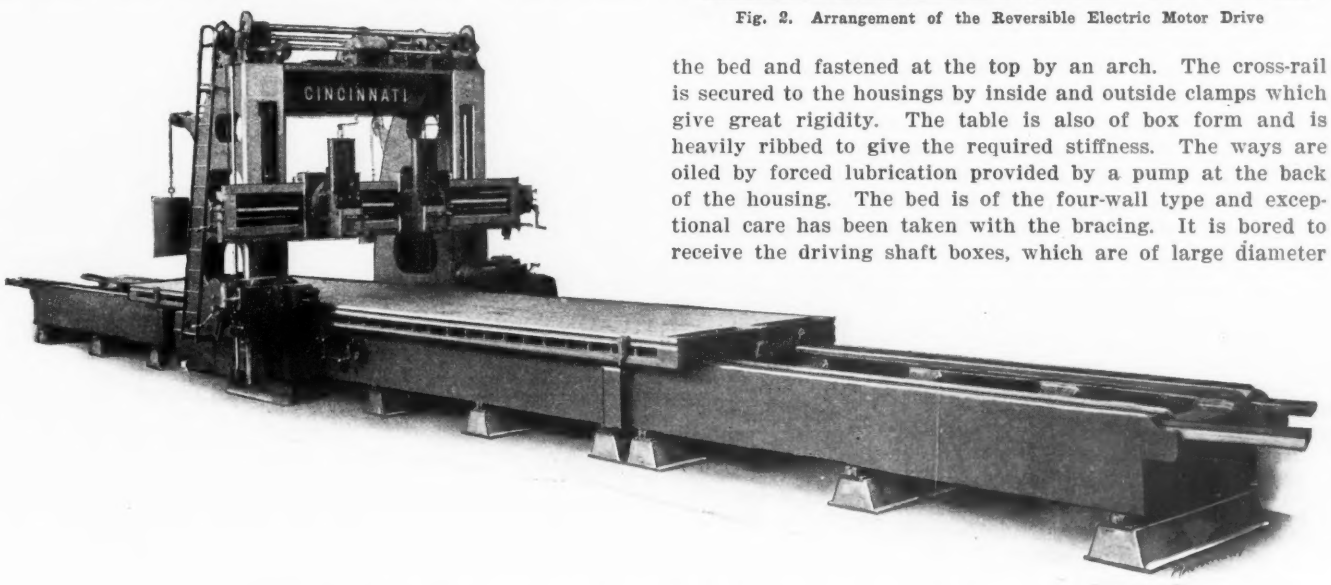


Fig. 1. Cincinnati 84-inch Planer equipped with Reversible Motor Drive and a 34-foot Table

the driving shaft through a flexible coupling. The motor controller is mounted on the housing. Planers of this type are being built in different sizes and lengths.

LANGELIER SWAGING MACHINE WITH SEMI-AUTOMATIC HOLDER

The swaging machine illustrated in Figs. 1 and 2 is a recent addition to the line of swaging machines built by the Langelier Mfg. Co., Providence, R. I. The functions of the machine and holder, taken as a unit, are to feed, reduce or size and automatically withdraw from the machine dies, solid stock, round, hexagonal, square or other sections requiring one plain unreduced butt or end and a reduced shank or blade. This machine handles such work as valve push-rods, nut tapper taps, single-butt automobile spokes, gun cleaning rods and similar parts ranging up to ½ inch diameter and from 8 to 14 inches long. The operator's duties consist only in loading, starting the machine, and unloading the holder; the swaging, feeding and withdrawing of the work from the dies is done automatically.

The reductions of stock are effected without waste of material or removing the surface. An idea of the economy of the swaging process both as to the saving of material and time of production may be obtained from Fig. 3, which shows the lengths of several blanks and also the lengths of the swaged samples. In addition, the saving in grinding expense may be considerable, as the parts are swaged very close to the finished size so that very little grinding is necessary. In many cases the parts are swaged so close to size that grinding is eliminated.

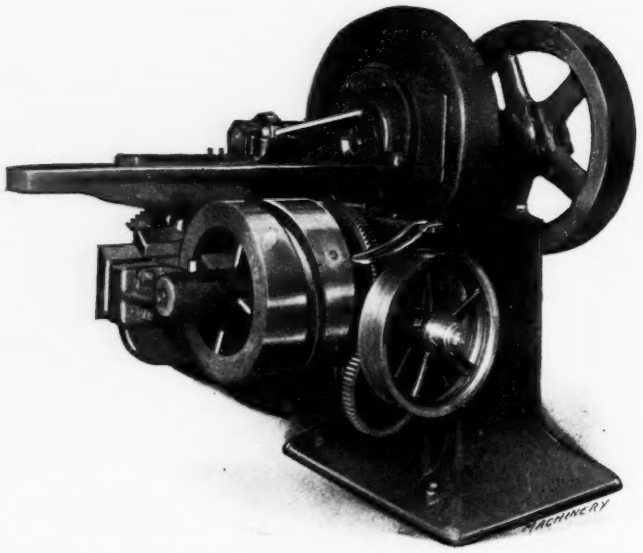


Fig. 1. Langelier No. 4 Swaging Machine with Semi-automatic Holder

The particular machine illustrated is so built that the size to be swaged can be controlled very closely. The machine is heavily constructed throughout to secure a rigid unit so that an unskilled operator can maintain steadily a high degree of accuracy and a large output without injury to the machine. The spindle, which is a vital part, is made unusually large and heavy. It is of hammered steel, turned and ground, and is bored the entire length so that long pieces can pass through and beyond the dies. The spindle is slotted across the enlarged end to receive a pair of hammer-blocks and dies. All sides of the slot are lined with hardened and ground steel plates securely riveted in place, thus practically enclosing the dies and hammer-blocks in a hardened steel box. This construction keeps the dies in true alignment and insures long life to the surfaces in contact.

The hammer-blocks carry on their outer ends two hardened and ground steel rolls which come into contact, during every revolution of the spindle, with a number of hardened steel rolls located in the machine head of the spindle. As the head rolls are in fixed seats, the hammer-blocks and dies are caused

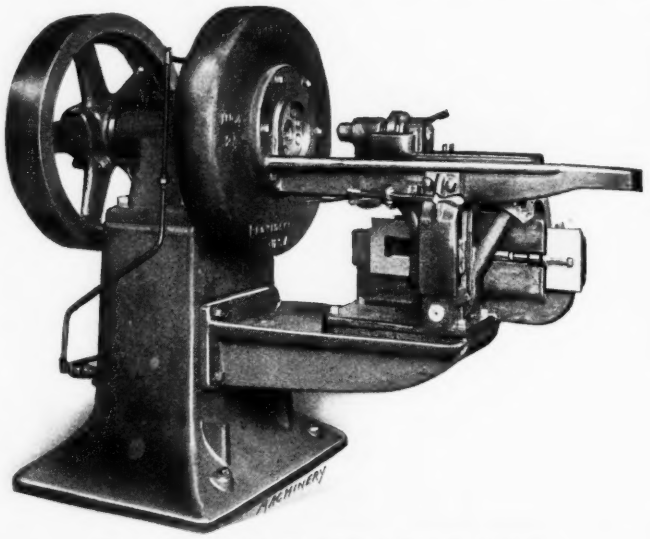


Fig. 2. Opposite Side of Langelier Swaging Machine illustrated in Fig. 1

to strike many sharp, quick blows in rapid succession for each revolution, thus producing a permanent set in the metal being swaged and imparting a high surface finish. The dies are made of high-speed steel and maintain their size for a long time. These dies can be quickly removed if desired. To control the proper die opening and maintain the reduced size required for the stock, two conical pointed screws are let into the front plate in the slotted end of the spindle and project into corresponding holes in the end of the hammer-blocks. Washers of the proper thickness are used under the heads of these screws to retain the distance which the conical screw points enter the hammer-blocks. By adjusting these screws in or out, different amounts of opening between the dies are obtained.

The spindle has an extra long bearing and is provided with loose floating sectional cast-iron bushings which serve to greatly decrease the surface velocity and increase the wearing surface. These bushings are perforated all over and the oil holes act as small reservoirs and serve to distribute the oil over the bearing as the bushings gradually revolve with the

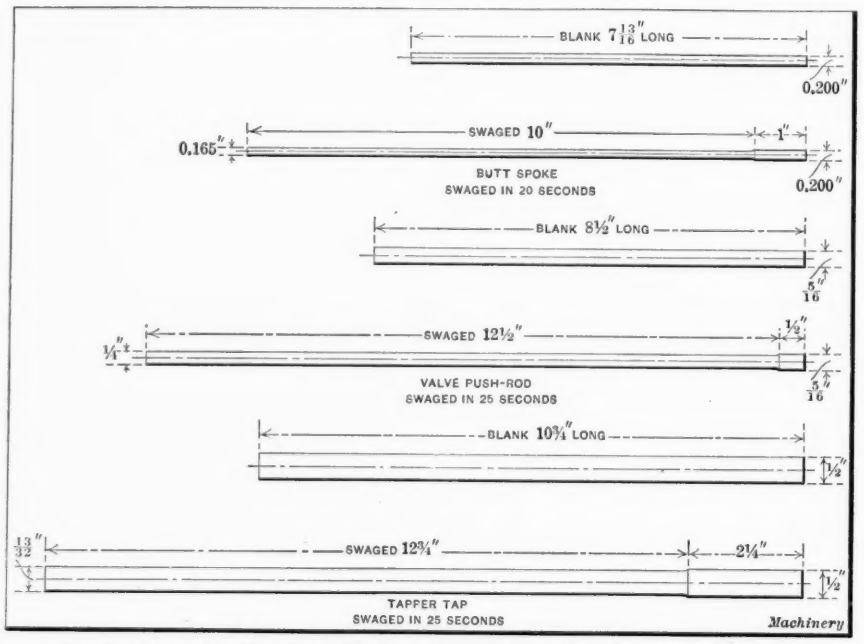


Fig. 3. Comparative Lengths of Blanks and Swaged Samples and Rate of Production

spindle. The flywheel is heavy and the hub is bolted and keyed to the spindle. At the rear end of the spindle a clamp nut is provided that serves both for taking up end play which

might occur as a result of long service, and for holding the flywheel in position endwise. An automatic oil pump driven from the main spindle, circulates oil through the running parts of the machine and is connected to the large oil reservoir in the machine base. The ample capacity of this reservoir permits running the machine a long time with only periodical attention to the oiling.

The holder consists of a rigid projecting rail bolted to the front of the machine, which provides long bearings on which a crosshead and saddle reciprocate. This crosshead carries an interchangeable and self-centering spring chuck with a hand lever tightener for holding the stock firmly, even when the grip is very short. The crosshead feeds the stock to be swaged, then it pauses slightly to allow the stock to be swaged neatly against the shoulder, joining the unswaged and swaged portions, after which it starts on the return stroke. The crosshead recedes at twice the feeding speed and the stock is automatically withdrawn from the dies; when near the end of the return stroke, the driving belt shifting device for the holder mechanism operates, thus shifting the belt to a loose pulley. This causes the holder to stop in the "loading" position. As the next blank is gripped by the chuck, the operator shifts the driving belt to the tight pulley, thus starting the crosshead again on the feeding or forward stroke. This cycle of motions is repeated for every blank.

The crosshead can be set at any desired position on the holder rail, and the forward or backward travel of the crosshead can be varied according to the length of the blank before and after swaging. The length of the feeding and return strokes of the crosshead are determined by the arc which a segment gear (partly shown in Fig. 1) which meshes with a rack on the under side of the crosshead saddle, describes as it is actuated by a straight-line movement of an adjustable stud on the lower crosshead. By setting this stud at different positions the length of the arc is varied. On the rear of this lower crosshead another stud is provided, carrying a roller which engages the large cylinder cam seen in Fig. 2. This cam is rotated by a wormwheel and worm driven through reducing gears and tight and loose pulleys, from the overhead countershaft.

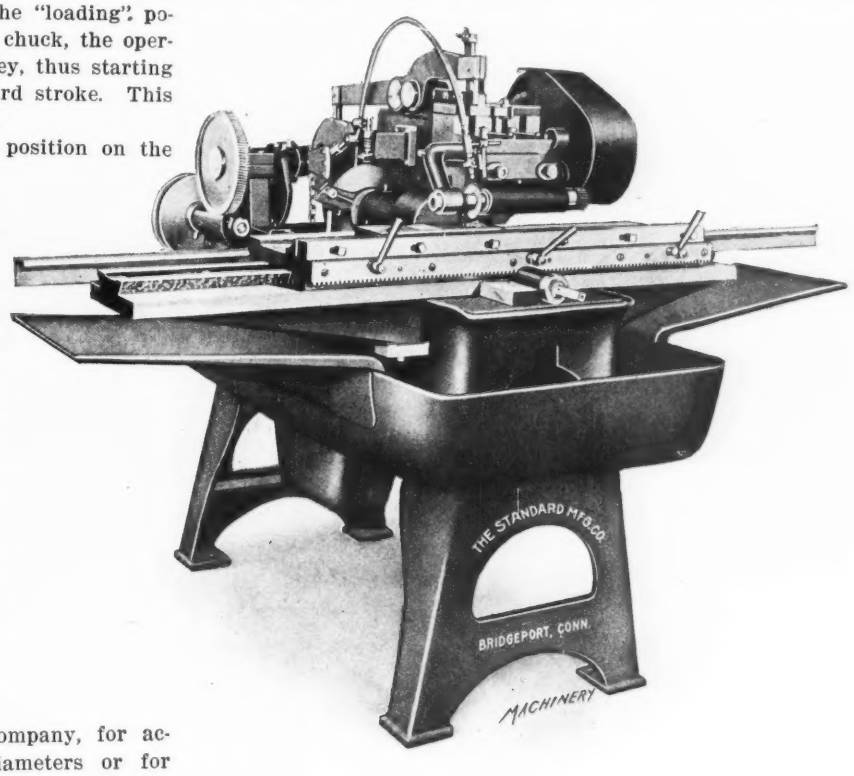
This same type of feeding and withdrawing mechanism can be applied to other types of swaging machines built by this company, for accommodating longer lengths and larger diameters or for reducing tubing. When equipped with high-speed steel dies 2½ inches long, the machine illustrated herewith reduces cold-rolled steel stock 0.311 inch in diameter down to 0.250 inch, in two operations. The feed is at the rate of 30 inches per minutes, and the piece is withdrawn at the rate of 60 inches per minute. Faster feed and return speeds can be used if the size and nature of the stock will permit.

STANDARD RACK CUTTING MACHINE

The Standard Mfg. Co., Bridgeport, Conn., has recently placed on the market an automatic rack cutting machine which has a capacity for work up to 30 inches in length. It will be seen from the illustration that this machine is provided with a deep oil pan equipped with detachable wings. This pan, in combination with an efficient oil pump, insures an adequate supply of oil being delivered to the cutter without the oil being splashed or wasted. The low substantial legs of the machine are a factor in providing for increased stability.

The cross-rail is keyed to the table, clamped by set-screws and fastened underneath. The vise is provided with long bearings and a gib on the inside to enable any wear which may develop to be compensated for. An adjustable steel jaw runs the entire length of the vise. The vise is equipped with a rack with which a pinion meshes that is operated by a crank; this rack and pinion provide for returning the vise to the starting position after the work has been completed. There is an adjustable trip for disengaging the feed when the work has been finished.

To insure accuracy and eliminate vibration, the cutter spindle bearing has been made of ample proportions, and an overhanging support is also provided to hold the arbor at its outer end. The slide which carries the cutter spindle is provided with both vertical and horizontal adjustment by means of screws, and a micrometer adjustment is provided for accurately gaging the depth of the cut. Four-stroke cams are regularly furnished for ordinary work and special stroke cams for special work. This machine has all the regular features of the Standard gear-cutting machines, such as quick return for the cutter; means for raising the cutter free of the work on the return stroke, thus obviating the necessity of again passing through the rack; and allowing the indexing to be done during the return stroke. The locking of the index plate, means of quickly changing the amount to be indexed and similar features of the gear-cutting machines have been retained on this rack cutter. If desired, the rack cutter may be converted into a gear-cutting machine. The rack cutter



Standard Rack Cutting Machine for Work up to 30 Inches in Length

is made in sizes corresponding to the Nos. 1, 2 and 3 gear-cutting machines made by the Standard Mfg. Co.

MONITOR A. C. MOTOR CONTROLLER

The Monitor Controller Co., Baltimore, Md., has recently perfected a controller for use on either single, two- or three-phase alternating-current motors. This controller is similar to the pre-set speed type of direct-current equipment manufactured by this company. With alternating-current motors, the dynamic brake for stopping cannot be used; consequently it is necessary to employ a foot-brake on the machine or a magnetic brake on the motor. Where the magnetic brake is used it can be operated from the new Monitor controller.

The accessories used with this new type of controller are identical with those used on the corresponding type of Monitor direct-current apparatus, *i. e.*, provision is made for starting, stopping and reversing the motor and for making slight movements of the machine. Every movement is controlled by either a push button or a safety lever, as shown in the illustrations. The distinctive feature of this controller is that, in starting the motor, a proper amount of resistance is automatically inserted in each phase which gives absolutely correct starting characteristics and is the same under all running conditions. The starting effort required of the motor is

the same, regardless of the position of the regulating handle. After the rotor has attained the proper speed, the starting resistance is automatically cut out by the controller, and the regulating resistance, which has been previously determined by setting the handle, is automatically thrown in, thus bringing the motor to the desired speed, which may be anything

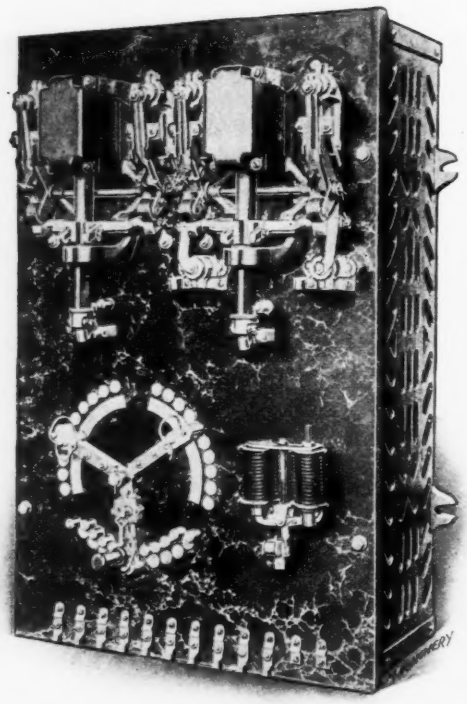


Fig. 1. Monitor Alternating-current Motor Controller

between normal and the lowest specified speed. A no-voltage release is provided with the controller so that in the event of a failure of the line voltage and the consequent stopping of the motor, the entire system is automatically cut out of the circuit and will not start again with the return of the voltage until the operator has moved the starting lever or button.

Fig. 2. Control Station

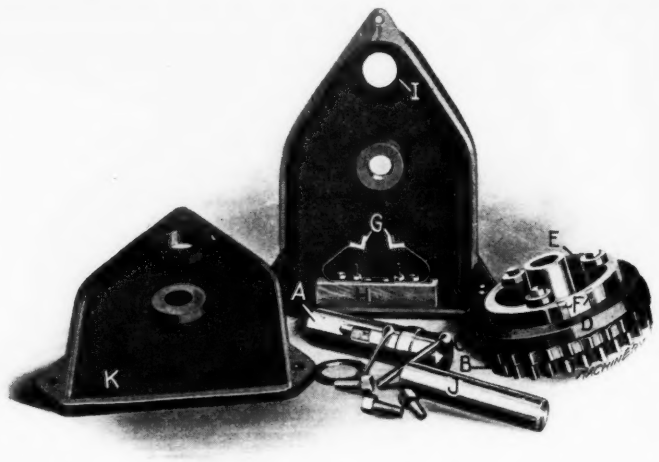
When this is done the starting cycle is again gone through, to place the motor in operation. These controllers are built for one or two motor drive, depending upon the amount of speed variation required, and will eventually be built in all sizes. At present they are made for motors whose rotor current does not exceed 150 amperes.

The control station shown in Fig. 2 is mounted on the machine, and in the case of large machines more than one of these stations will be used. The lever is shown in the "start" position at *A*, the "ready" position at *B* and the "stop and safety" position at *C*.

CLEVELAND CRANE LIMIT SWITCH

In order to perform its essential function of protection in the face of careless operation, a crane limit switch must be designed in such a way that it will always be in operating condition when required. It is impossible to design any mechanical device that will not sooner or later get out of order, and in the case of a limit switch the essential feature is to have an arrangement which will give warning if there is anything wrong. In the closed circuit type of limit switch made by the Cleveland Crane & Engineering Co., Wickliffe, Cleveland, Ohio, this idea has been applied by connecting the switch into the hoist motor circuit in such a way that the electrical operating parts are always charged with current when the hoist is in operation. Should any defect—such as a broken wire or loose connection—develop, it at once throws the motor out of commission the same as though the hoist had been run up to the limiting point. In this way, positive assurance is obtained that the switch mechanism is unfailing in its action when the hoist is running. A feature of the design is the simplicity and accessibility of all parts and the facility with which the switch may be installed.

The parts of this limit switch are shown in the accompanying illustration, from which the method of operation will be readily understood in connection with the following description: The tripper *A* is connected to one end of the hoisting drum shaft by two pins driven into the end of the



Cleveland Closed Circuit Type of Crane Limit Switch

drum shaft. Four holes drilled in the end of the tripper allow for one-quarter turn positive adjustment. A tooth at the end of the tripper engages one tooth of the tripper sprocket *B* at each revolution of the drum. An oval recess cut at the side of the tooth in the tripper permits the check sprocket *C* to rotate while the tripper tooth is engaged in the tripper sprocket. The conformation of the teeth on the outside of the check sprocket to the contour of the tripper prevents the sprocket wheel from turning while the tripper is completing the revolution. Attached to the sprockets by small insulated through bolts is a fiber insulating ring *D* and a brass contact ring *E*. Two fiber contact blocks *F* are inserted in the brass contact ring at a distance apart which depends upon the number of revolutions of the drum required to raise the hoist block between the two extreme positions. Mounted on a fiber block *H* are two contact springs *G* which form electrical connection with the brass contact ring *E*. The circuit leads are attached to terminal posts on the contact springs and are connected to the coil of a magnetic switch which controls the hoist motor current, the switch being located in the cage within easy reach of the operator. When the block reaches the limit of its travel, the switch is opened by the breaking of the circuit in the switch coil, due to the contacts *G* resting on the fiber blocks *F*. The cast-iron box *I* encloses the entire mechanism and is attached to the frame of the trolley by through bolts. One end of the pin *J* which carries the

contact ring and sprockets is held by a bearing in the box, and the other end by a bearing in the cover *K*. The tripper pin is supported in the same way. When the cover is removed from the box every part is instantly accessible and may be readily removed. The small size of this switch makes it particularly convenient to install.

BROWN & SHARPE GEAR CUTTING MACHINES

In developing the Nos. 3-H and 13-H automatic gear cutting machines (Figs. 1 to 4), the intention of the Brown & Sharpe Mfg. Co., Providence, R. I., has been to produce machines that are adapted for taking heavy cuts on coarse pitch gearing and at the same time produce work of a high degree of accuracy. With this idea in view, particular care has been taken in the distribution of the metal to secure the greatest possible rigidity and consequent freedom from vibration. The wheels and levers for controlling all of the movements, as will be seen in the illustrations, have been placed at the front where they are within easy reach of the operator. This is obviously a great convenience in setting up work and in the subsequent operation of the machine. Referring to the illustrations, it will be evident that the No. 3-H machine shown in Figs. 1 and 2 is simply adapted for cutting spur gears, while the No. 13-H machine is intended for cutting both spur and bevel gears. The design and construction of the two machines is essentially the same with the exception of the cutter slides. The No. 3-H machine is described first and the same descriptive matter will apply to the No. 13-H machine with the exception of the cutter slide and one or two other details which will be referred to.

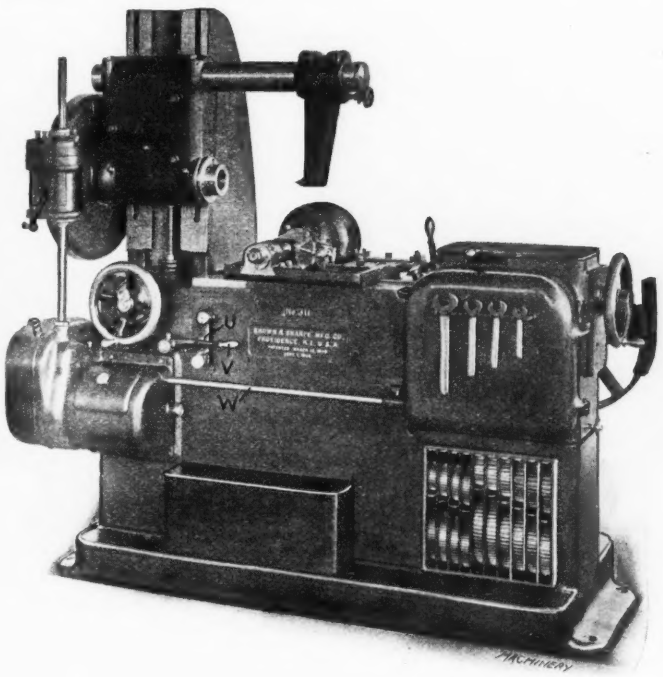


Fig. 1. Front View of Brown & Sharpe No. 3-H Gear Cutting Machine

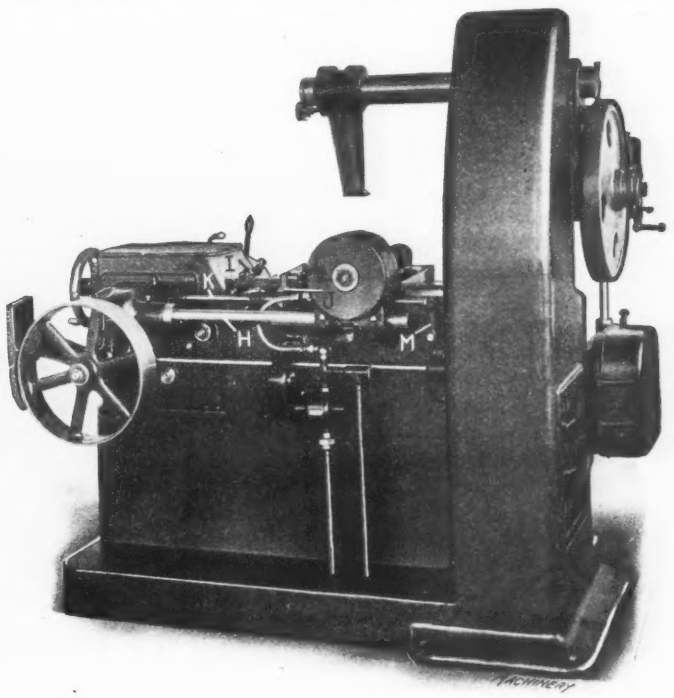


Fig. 2. Rear View of No. 3-H Gear Cutting Machine

The No. 3-H Spur Gear Cutting Machine

Referring to the rear view of the No. 3-H machine illustrated in Fig. 2, it will be seen that the drive is through a single pulley. In the line-cut Fig. 5 *A* is the shaft on which the driving pulley is mounted. The feed of the cutter slide is taken from this shaft by means of spur gears which transmit through the shaft *B* to the change gear box shown at the right-hand end of the machine in Fig. 1. From the change gear box the drive is back through the shaft *C* which carries a worm meshing with the feed worm-wheel *D* mounted

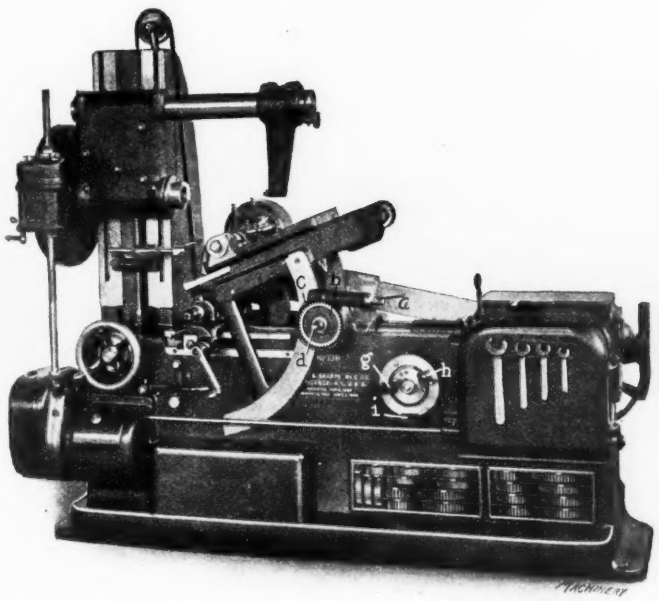


Fig. 3. Front View of Brown & Sharpe No. 13-H Gear Cutting Machine

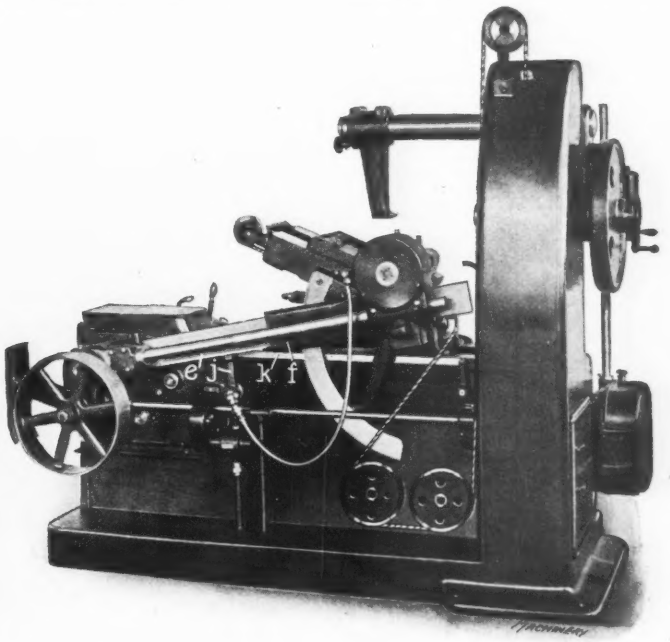


Fig. 4. Rear View of No. 13-H Gear Cutting Machine

on the feed shaft *E*. The cutter slide is moved by this threaded feed shaft. Sixteen changes of feed are provided by the change gears; these feeds are in geometrical progression and cover a range of from 13/16 to 15 3/4 inches per minute.

The speed changes for the rotation of the cutter are obtained by change gears in the same box in which the feed gears are mounted. The drive to the cutter is carried back through the shaft *F*, Fig. 5, which drives the shaft *H*, Fig. 2, by means of bevel gears. There are twelve speed changes provided which are in geometrical progression and cover a range of from 30 to 156 revolutions per minute. An outer bearing has been provided for the cutter spindle which gives additional support to adapt the machine for heavy classes of manufacturing work. Another distinctive feature is the application of a heavy balance wheel on the cutter spindle. This balance wheel is employed to carry the cutter through hard spots in the work or to compensate for any other inequalities that would have a tendency to cause the speed of rotation to vary.

When the cutter has been fed across the face of the work, the movement of the cutter slide is reversed by the action of the dog *I* which engages the stop *J* mounted on the horizontal shaft *K*, Fig. 2. The operation of the mechanism may be briefly explained as follows: When the dog *I* engages stop *J* it continues to move forward and carries the stop with it. This, in turn, carries the shaft *K* forward and operates the clutch mchanism shown in the line-cut, Fig. 6. This illustration shows the feed worm-wheel *D* and the quick return worm-wheel *G* which are mounted on the cutter-slide feed rod. Either of these worm-wheels may be secured to the feed rod by means of an intermediate clutch which is operated by the arrangement of the dogs shown in Fig. 2. When the dog *I* engages the stop *J* and pulls the shaft *K* forward, a stop on the end of the shaft *K* engages with the end of the lever *N*, Fig. 6. Further movement of the shaft *K* causes the lever *N* to swing on its pivot; and the roller carried at the lower end of the lever *N* runs over the pointed plunger *O* and pushes this plunger down against a compression spring. This movement

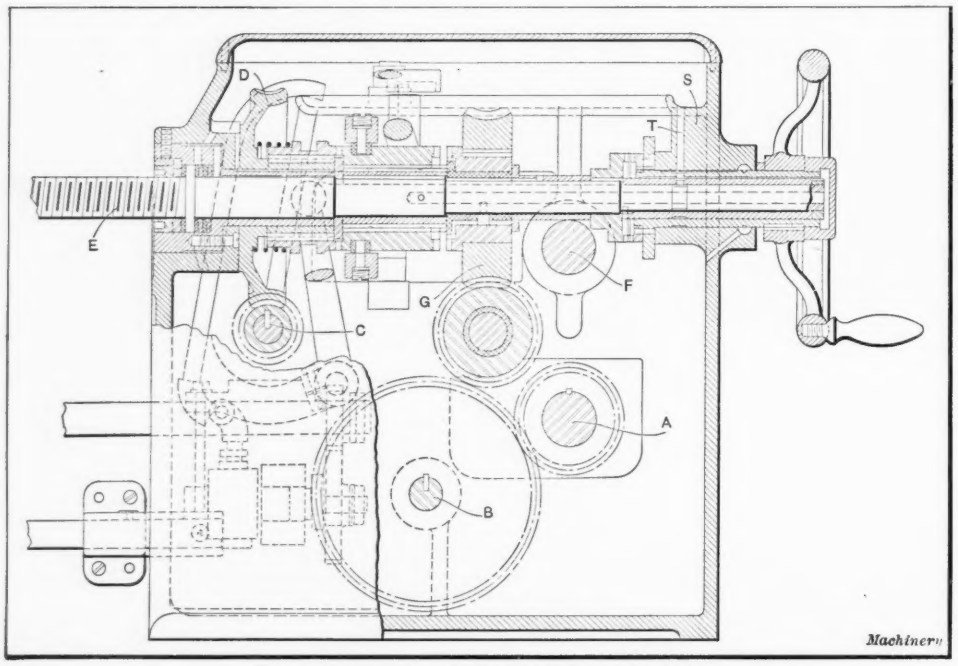


Fig. 5. Arrangement of Feed and Quick-return Drives

continues until the roller has passed the top point of the plunger, when the action of the spring causes the lever *N* to be thrown over with great rapidity.

A pin carried by the lever *N* works in a slot in lever *P*. At the time when the roller has reached the top of plunger *O*, this pin is engaged with the end of the slot and further movement of lever *N* causes a corresponding movement of lever *P*. The cam surface at the lower end of lever *N* engages with the projection *Q* on the locking plunger *R* and causes this plunger to be pushed down against the tension of a spring. The depression of the plunger releases the clutch from the feed worm-wheel *D* and allows it to be thrown over by the action of lever *P* so that it engages with the quick return worm-wheel *G*. When the clutch engages with the worm-wheel, it is locked in engagement by means of the locking plunger *R'* and remains locked until the carriage has been returned to the starting point. The clutch is then released from the return worm-wheel and thrown back into engagement with the feed worm-wheel. Referring back to Fig. 5 it will be seen that the quick return worm-wheel *G* is geared direct to the main driving shaft *A* by means of a pair of spur gears. This drive allows the cutter slide to be returned at fifteen feet per minute.

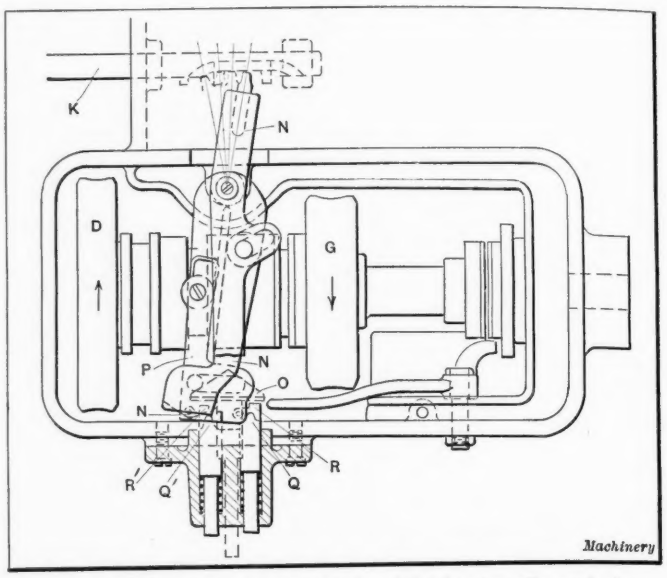


Fig. 6. Mechanism for engaging Feed and Quick-return Worm-wheels

A handwheel is provided at the end of the feed shaft for feeding the cutter slide by hand. This wheel is secured to the shaft by sliding it into engagement with a clutch. It is evident that when the feed of the cutter slide is reversed so that the quick return comes into action, the handwheel would be rotated in the opposite direction at a high speed. Were such a condition allowed to take place, there would be a risk of injuring the operator. To avoid this danger, a lever is provided which acts automatically to throw the handwheel out of engagement with the clutch before the quick return is engaged. This lever is operated by the lever *N*, Fig. 6, from which the arrangement will be readily understood.

It will be remembered that the maximum feed employed on this machine is 15¾ inches per minute while the cutter slide is always returned at the rate of 15 feet per minute. Evidently this change of speed in connection with the reversal of the cutter slide would result in subjecting the gearing to a serious shock. To overcome this difficulty, the arrangement shown in Fig. 7 has been employed. In this illustration *G* is the worm which meshes with the quick return worm-wheel on the feed shaft. At the moment when the clutch engages with the quick return worm-wheel, the worm is allowed to move over on its shaft against the tension of a stiff spring, and in this way the shock of reversal is taken up by the spring instead of being borne by the gearing. This eliminates damage to the gearing and also does away with the shock and consequent vibration which would result if such a method were not employed. This method of

taking up the shock is a new device which has been recently adopted.

When the cutter slide is being returned to the starting point the dog *L*, Fig. 2, engages with the stop *J* carried on the shaft *K*. This causes the lever *N*, Fig. 6, to be thrown in the reverse direction. The roller on lever *N* acts over the spring plunger *O* as previously described and causes the cam on lever *N* to disengage the locking plunger *R'*. In this way, the clutch is released from the quick return worm-wheel *G* and comes into engagement with the feed worm-wheel *D*. The cutter slide is then ready for the next cut. The dogs *I* and *L* are adjustable so that the traverse of the carriage may be regulated as desired.

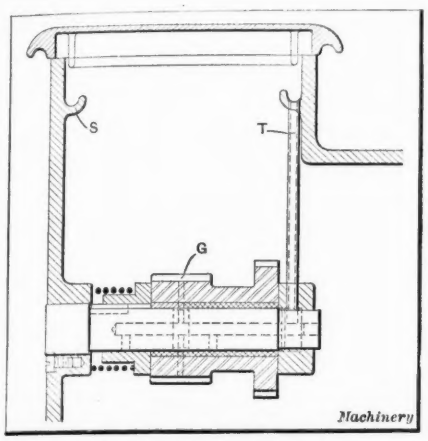


Fig. 7. Spring for absorbing Shock of Reversal and Oil Trough

The gear pump which is provided for supplying lubricant to the cutter is shown in the rear view of the machine illustrated in Fig. 2. This pump delivers lubricant from a large tank which extends all of the way under the machine. This tank is of ample size to insure having an abundance of cool lubricant available at all times ready to be supplied to the cutter. The chips and oil drop down into a pan located under the work. This pan is perforated at the bottom to allow the oil to drain back into the reservoir while the chips are retained so that they may be easily removed.

The gear-box which provides the feed and speed changes is now built as a unit ready to be mounted on the machine, instead of having the different parts of the change gear mechanism assembled in the machine as separate pieces. An improved method of lubrication has also been applied on these machines. This consists of a geared oil pump which delivers lubricant to a trough *S* shown in the sectional views, Figs. 5 and 7. Small brass taps *T* are let into the bottom of this trough which deliver oil to all of the bearings. The oil from the bearings runs back to the reservoir from which it is pumped back to the trough *S*. In this way there is a continual flow of oil being delivered to all of the bearings.

The index mechanism is driven by the lower of the three horizontal shafts shown at the back of the machine in Fig. 2, and the index mechanism is contained in the case shown at the left-hand end of the machine in Fig. 1. Provision is made for cutting all numbers of teeth from 4 to 50 and all numbers from 50 to 400 except prime numbers and their multiples. The placing of the indexing mechanism at the front of the machine is one of the changes referred to in placing all control levers within reach of the operating position. Another change was that of placing the change gears for the index mechanism as shown in Fig. 2, where they are particularly convenient for the operator. The operation of the index mechanism is entirely independent of the speed of the cutter and the rate of feed that is being employed, the indexing taking place during the period that the cutter slide is being returned. Indexing occurs when the cutter slide has reached the end of its reverse stroke.

The way in which the indexing is effected is as follows: When the dog *L* engages the stop *J* and pulls the shaft *K* backward, Fig. 2, it swings the lever *M* to the left. This lever is carried on a shaft which extends through to the front of the machine and has the small lever *U* mounted on it. The movement of the lever *M* rocks the lever *U* and throws up the lever *V*. The movement of the lever *V* engages the index mechanism and at the same time disengages the feed through the action of horizontal shaft *W* which extends from the index mechanism to the feed change gear-box. This shaft *W* trips an arrangement of levers which positively disconnects the clutch from the feed worm-wheel. The arrangement of the index mechanism is essentially the same as that employed on the standard No. 3 machine. One slight change may be mentioned in connection with the method of disengaging the worm from the index worm-wheel in order to enable the work to be rotated by hand. This is done by releasing the binder lever *X*. It will be seen that the upper and lower sections of the case in which the worm is mounted are secured to the case over the worm-wheel. The central section can be swung back when the binder lever is released, and in this way the worm is disconnected from the worm-wheel so that the work may be rotated. This device is found to be a decided convenience in setting up work and making adjustments.

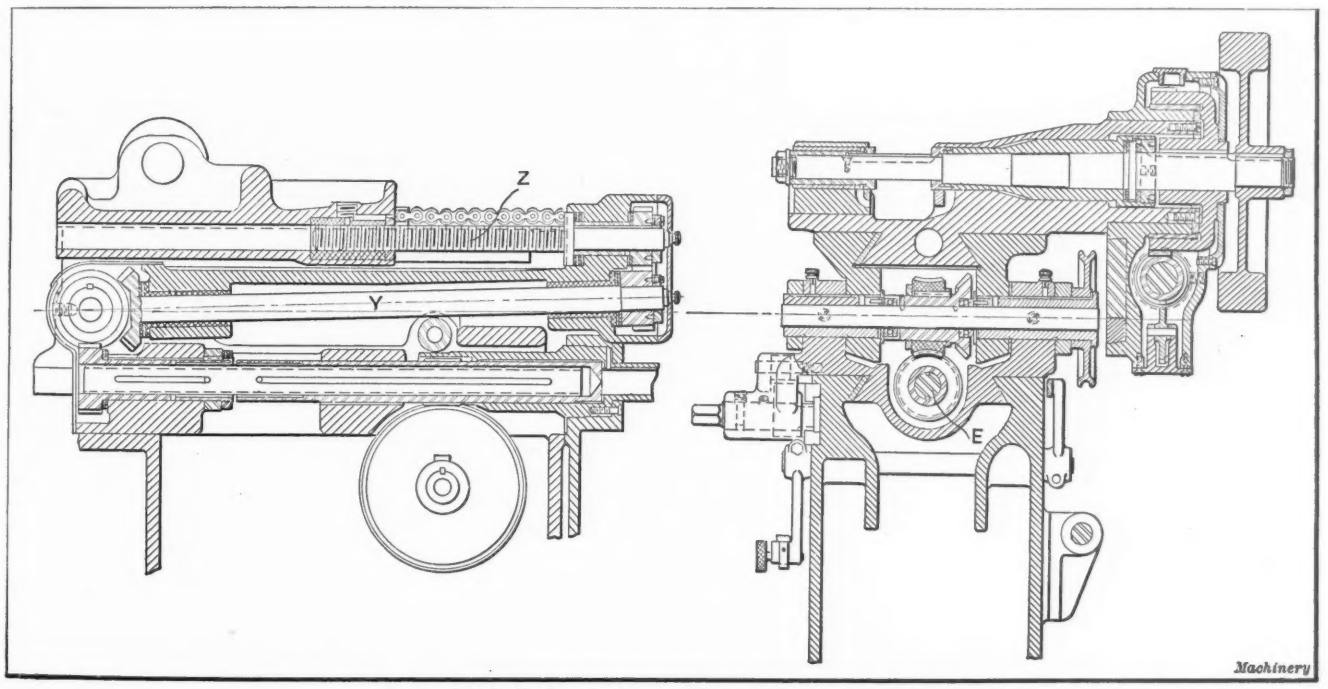


Fig. 8. Longitudinal and Cross-sectional Views of Cutter-slide

The arrangement of the work-spindle slide is evident from the illustrations. In this connection it may be mentioned that a departure from preceding designs of Brown & Sharpe gear cutting machines has been made in the introduction of T-slots in the face of the upright to which the work-spindle slide is clamped by three bolts. The slide is adjusted by means of a screw and handwheel equipped with a dial graduated to 0.001 inch, which facilitates making accurate settings of the depth to which the teeth are to be cut. The thrust on the

screw is taken by a ball bearing. The work-spindle has a No. 14 taper hole and is fitted to receive a faceplate or fixture. There is a hole through the spindle 1 13/16 inch in diameter which provides for the use of a bolt to clamp the mandrel upon which the work is carried in place in the spindle. The over-arm construction employed on this machine is particularly heavy, and as shown in the illustrations, the outboard support is fitted with an adjustable center to engage the mandrel. When so desired, a bushing may be used instead of this center.

The capacity of the No. 3-H gear cutting machine is for spur gears up to 24 inches in diameter and up to 8 inch face width. Gears as large as 3 diametral pitch may be cut from cast iron and 4 diametral pitch in steel. The machine occupies a floor space 85 inches in length—measured at right angles to the cutter spindle—by 45 inches in width. The net weight of the machine is about 4400 pounds.

No. 13-H Combination Spur and Bevel Gear Cutting Machine

Front and rear views of the No. 13-H combination spur and bevel gear cutting machine are illustrated in Figs. 3 and 4. The arrangement of the drive, the change gears for the feed and speed of the cutter, the method of indexing and the design of the work-spindle slide are essentially the same as on the No. 3-H machine. The difference in the design of the No. 13-H machine lies in the provision for making angular settings of the cutter slide for handling bevel gears. First among the improvements in this machine may be mentioned the provision of two segment gears for elevating the cutter slide instead of a single gear. It will be seen that the two segment gears are located at either side of the machine and in connection with the two trunnions which support the cutter slide provide four points of support. This effectually does away with any tendency for the cutter slide to tilt out of alignment.

Fig. 8 shows cross and longitudinal sectional views through the cutter slide. In this illustration *E* is the feed rod which remains in a horizontal position in the base of the machine. This rod drives the feed-screw in the cutter slide by means of a worm and worm-wheel, a pair of bevel gears and an intermediate shaft *Y* which transmits the motion to the feed-screw *Z* through a pair of spur gears. It will be evident that the use of the worm and wheel and the pair of bevel gears allows the cutter slide to be set at any required angle. The angular settings of the slide are made by means of a crank fitting onto the squared shaft *a*, Fig. 3. This shaft carries a worm meshing with the worm-wheel *b* and the worm-wheel drives a pinion which meshes with the segment gear. Any angle up to 90 degrees may be obtained by means of a scale graduated on the inner edge of the segment gear. This scale runs under the indicator *c* which acts as the reference point in making angular settings. After the desired setting has been obtained, the slide is clamped in place by means of a wrench fitting over the end of the squared shaft *d*.

When the slide is set to angles greater than 30 degrees, a counterweight is employed to relieve the pressure that would come on the feed-screw. This weight is supported by a cable running over pulleys, the arrangement of which is clearly shown in Fig. 4. The counterweight runs down inside the upright of the machine, which represents another improvement in design. This arrangement eliminates the possibility of the weight falling and injuring a workman. To protect the shaft which drives the cutter from strain, a supporting member *e* has been provided, as shown in Fig. 4. This support is trunnioned at the left-hand end of the machine and runs in a bearing *f* which is pivoted to the cutter slide.

The method by which the feed and quick return of the cutter slide are obtained is slightly different from that employed on the No. 3-H machine. On the No. 13-H machine the dogs *g* and *h*, Fig. 3, rotate and engage with the stop *i*. This stop is at the end of a crank carried by a shaft which extends through to the back of the machine, Fig. 4. This shaft carries a crank *j* which moves the horizontal link *k*. This link corresponds with the horizontal shaft *K* on the No. 3-H machine. The operation of the clutches and indexing mechanism from the link *k* is then exactly the same as described for the No. 3-H machine.

The capacity of this machine is for spur or bevel gears up to 24 inches in diameter by 6 inches face width. Cast iron gears up to 3 diametral pitch may be cut and steel gears up to 4 diametral pitch. The floor space occupied is 103 inches long—measured at right angles to the cutter spindle—by 46¾ inches in width. The net weight of the machine is about 5300 pounds.

"STANDCO" HOLLOW SET-SCREW

The "Standco" hollow set-screw is a recent product of the Standard Pressed Steel Co., Philadelphia, Pa., for use in connection with the "Hallowell" cold-rolled steel safety set-collar of this company's manufacture. These hollow set-screws are made from steel bar stock of a special analysis which has been found exceptionally well suited to this purpose.

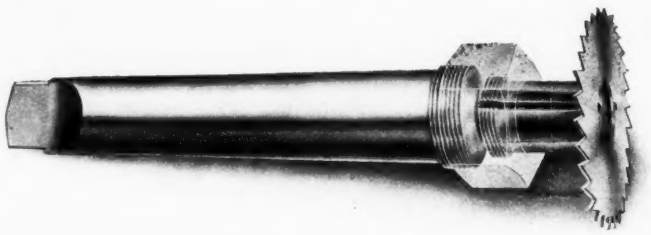
The "Standco" Hollow Set-screw

The heat-treatment and hardening process to which these set-screws are subjected have been given particularly careful attention with the result that they are uniform in hardness and toughness and able to stand up under the most severe service. "Standco" safety set-screws are made with either a hexagonal or a square hole, and in almost any diameter and length. They are furnished with different forms of threads and points to suit the requirements of a variety of classes of service for which they are adapted in addition to their application on the "Hallowell" set-collars.

GRANT INTERNAL GRIP ARBOR

There are many milling operations where the nut or the end of the arbor extending out beyond the cutter interferes with the work or clamps, and in such cases end or face mills have to be used. The effective radius of cutters and saws used on an ordinary arbor is also reduced by an amount equal to the thickness of the wall of the clamping collars. To overcome these difficulties the Grant Mfg. & Machine Co., 80 Silliman Ave., Bridgeport, Conn., has brought out an internal-grip arbor which is shown in the accompanying illustration. No nut is used on this arbor that would interfere with the work and, for any given operation, the size of the cutter or saw that is required is materially reduced.

This arbor has the usual form of taper shank, and at the opposite end there is a tapered extension over which fits a



Grant Internal-grip Arbor for Milling Cutters and Saws

split sleeve. The end of this sleeve is threaded left-hand, while the end of the arbor is threaded right-hand. The sleeve is first screwed into the clamping nut, after which the nut is screwed onto the arbor. This causes the split sleeve to be drawn up on the tapered end of the arbor and expanded sufficiently to secure a firm grip on the inside of the cutter. To release the cutter from the arbor it is merely necessary to loosen the nut.

Many shops are not well equipped with face milling cutters and the arbors are holding them. The use of this internal-grip arbor enables ordinary side-tooth cutters to be employed for face milling operations, thus adding materially to their

field of usefulness. The sleeves provided for use on these arbors are made in different lengths to suit all cutters of ordinary width. An arbor of this type is also made, which is adapted for use in the vertical attachment for the milling machine. This allows the entire equipment of standard cutters in a shop to be used in the vertical attachment, where formerly only end-mills or special cutters provided with taper shanks could be employed. The standard arbors of this type are made with either No. 9 or No. 10 B. & S. taper shanks, and they are equipped with sleeves for cutters having holes ⅞ or 1 inch in diameter.

THE BRIGHT BALL-BEARING HANGER

The Hess-Bright Mfg. Co., Front St. and Erie Ave., Philadelphia, has introduced a new ball-bearing hanger which is the result of a careful study of hanger requirements. Before referring to this hanger it may be well to call attention

Fig. 1. Bright Ball Bearing Hanger of Universal Swiveling Type

to some of the reasons for its construction and arrangement. As is quite generally known, the ball-bearing hanger formerly manufactured by this company consists principally of a box frame carrying a heavy yoke which is free to swivel about a vertical axis and contains the box and bearing. The box is held within the yoke upon horizontal set-screws, thus providing a universal swiveling movement for the bearing and box. This hanger, which was developed from the four-point screw suspension type, has given satisfactory results,

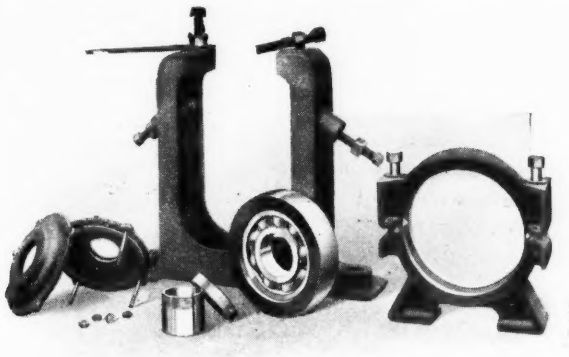


Fig. 2. Component Parts of the Bright Ball Bearing Hanger

although in some instances trouble was experienced because of careless erection. If a millwright when installing the hanger tightened the two horizontal set-screws (which hold the bearing and box within the yoke) excessively, the box body and hence the bearing might be distorted, and even if this distortion were very slight it would subject the close-fitting balls to enormous pressure as they passed the narrow places thus formed between the races. To make it impossible to distort the bearing in this manner and, at the same time, retain the universal swiveling movement the new hanger shown in the accompanying illustrations was designed.

This hanger was originated by Mr. Fred E. Bright, President of the Hess-Bright Mfg. Co. It has a rigid box frame, the jaws of which are flanged on the inside to retain a yoke which holds the bearing box and bearings. This yoke is divided on the horizontal center line, and it is securely held in position by four set-screws which come against the base. Two of these set-screws bear against the bottom of the base and provide vertical adjustment, whereas the other two set-screws are inserted through the sides, near the base, at an angle of 45 degrees and bear against a surface on the base which is at right angles to them. With this arrangement the yoke is held securely, but the clamping screws cannot possibly cause distortion of the box as the result of excessive tightening. The yoke is provided with a machined spherical seat for the box which contains the ball bearing. This feature enables the bearing and box to swivel in any direction. The bearing is enclosed within the box, and as both move together in case there is any deflection of the shaft only a very slight clearance is required between the shaft and the box covers at the ends, thus excluding dust and protecting the races and balls. This improved form of swiveling box and bearing will be applied to the post type of hanger and also to floor stands and pillow blocks.

GARDNER PATTERNMAKERS' ROLL SANDER

The roll sanding machine shown in the accompanying illustration is made by the Gardner Machine Co., Beloit, Wis., and is used in making wood patterns. A typical application

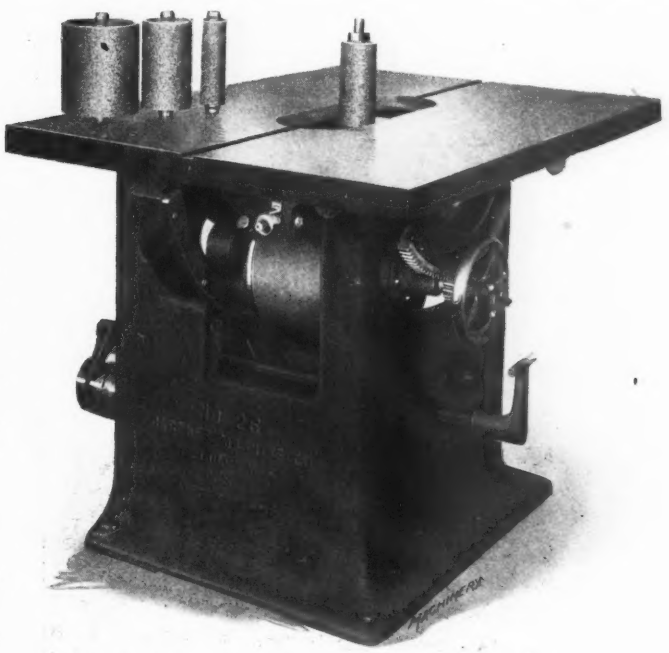


Fig. 1. Gardner Patternmakers' Roll Sander

of the machine is for finishing core boxes. The cutting member consists of a metal roll covered with a strip of "netbac" garnet paper. This strip of paper is joined on an oblique line in order to avoid the "chug" which would take place at each revolution if the ends were butted on a perpendicular line. The roll, which oscillates slightly up and down, is driven by a friction pulley, and its speed can be increased or diminished according to the size of the roll which is being used. This speed adjustment is made by a regulator screw located on the under side of the housing; and a speed variation of from 2000 to 6000 revolutions per minute can be obtained. The equipment includes four rolls, which are 7 inches long by 2, 3, 4 and 6 inches in diameter, respectively. The smaller the roll, the higher the speed required in order to obtain an efficient cutting speed.

Helical hardened steel gears are used to produce the oscillating motion of the roll spindle. Instead of tilting the table for sanding work at an angle, simple means are provided for tilting the roll spindle and locking it in any required position,

as shown in Fig. 2. This allows the operator always to work with the table flat, which is said to be an advantage. The angle to which the roll is tilted is accurately indicated by graduations located on the rim of the segment gear directly behind the handwheel. The opening in the table through which the roll passes is elongated to provide for moving the table laterally. This lateral motion, which is governed by a screw equipped with a micrometer dial, is utilized when fix-

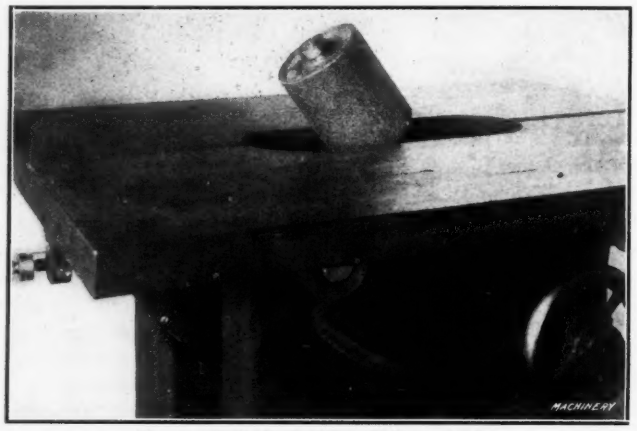


Fig. 2. Method of tilting Roll on Sander

ture are employed in sanding a large number of duplicate pieces. If small pieces of work are to be sanded, the opening in the table around the roll is closed by dropping a removable plate into place, this plate usually being made of hard wood. One of these plates is shown in use in Fig. 3. The table is 36 inches wide by 48 inches long and the height from the floor is 36 inches.

It will be evident from the preceding description and illustrations that this machine is adapted for sanding both in-

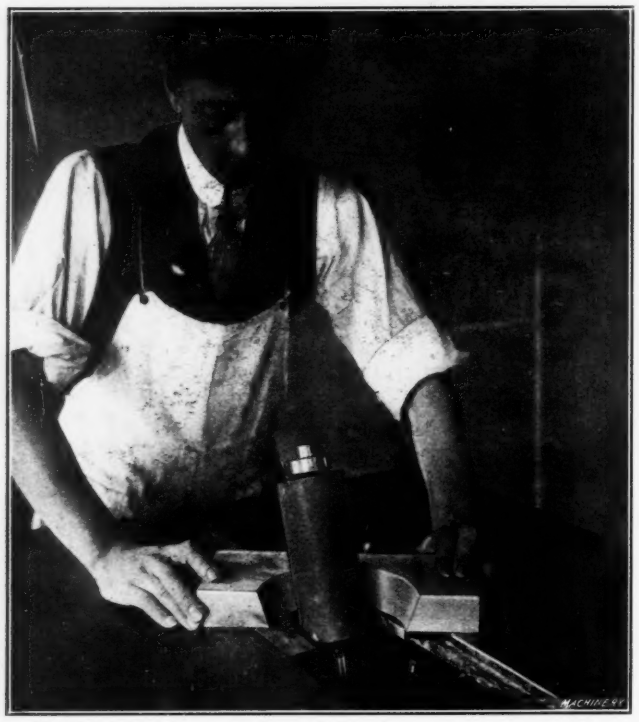


Fig. 3. Finishing an Internal Angular Curve on Gardner Sander

ternal and external work with either perpendicular or inclined faces. Fig. 3 shows the method of finishing an internal, inclined curve. This is typical of a class of work which is frequently met with in almost every pattern shop, the piece shown being the head of a core box for an ordinary straight core. For handling this work, the roll is tilted to an angle of 20 degrees and the operator simply follows the line which has been laid out on the work. The convenience of having the table flat is particularly marked on work of this kind. A feature of this sanding machine is that knots, nails, or the grain of the wood do not interfere with its operation in any way. The complete equipment includes four rolls, cement and an assortment of "netbac" garnet strips. No countershaft is required. A dust hood can be suspended from above to keep the top of the table clear. The floor space occupied is 6 by 8 feet and the complete weight of the machine 1700 pounds.

MC CROSKY VARIABLE SPEED AND REVERSING ATTACHMENT

The "Wizard" variable speed and reversing attachment for drill presses shown in Figs. 1 and 2 is a recent product of the McCrosky Reamer Co., Meadville, Pa. This attachment combines the functions of a drill speeder and tapping attachment, with an addition of two speed changes. By operating the small knurled handle at the front of the attachment either of three forward speeds may be obtained; the rotation of the tool is also reversed by this handle. As an example of the work for which this attachment is intended, consider a case in which it is necessary to drill a small and a large hole and tap one of the holes. The variable speed feature provides for driving the small drill at a high speed and the large drill at a low speed, while the reverse enables the tap

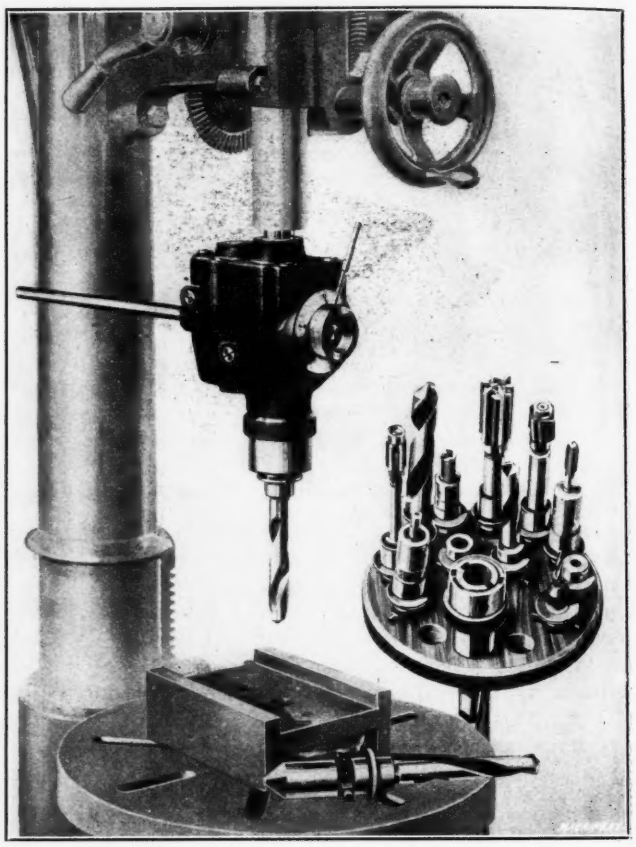


Fig. 1. Drill Press equipped with McCrosky Attachment

to be backed out of the work after the tapping operation is completed. The tapping may be done at slow speed and the tap backed out at high speed.

All bearings are bushed—the four main bearings with special cast iron and the loose gears with phosphor-bronze. There are no sliding gears, the transmission being effected by two positive clutches. All gears are of hardened steel. Taps, large drills and similar tools should be run at the slow or direct speed and for such work the gears run idle. The direct speed is the same as the speed of the drill press spindle and, of course, can be easily regulated to suit the work in hand. The intermediate speed is about two and one-half times faster than the direct speed, while the high speed is about five times that of the spindle.

This attachment is regularly furnished with the "Wizard" quick-change collet chuck. This chuck is used in connection with individual collets which are kept on the different tools which are used in succession in machining a piece of work. By holding the knurled sleeve on the chuck back against the rotation of the spindle the collet carrying the tool which has finished its operation may be removed without requiring the machine to be stopped. A fresh tool is mounted in the chuck in the same way, it being merely necessary to hold the sleeve

back against the rotation of the spindle and then slip the collet up into the chuck. In Fig. 1 a drill press is shown equipped with one of these McCrosky variable speed and reversing attachments. Beside the table of this machine a rack will be seen in which a series of tools mounted in col-

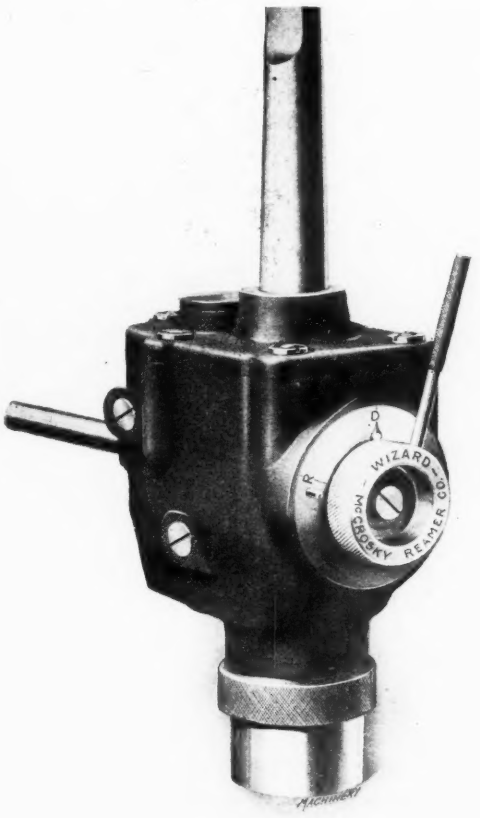


Fig. 2. McCrosky Variable Speed and Reversing Attachment

lets are carried. The ability to operate the tool at the most desirable speed and to make quick changes from one style of tool to another materially reduces the cost of machining operations.

WALDEN COMBINATION SOCKET WRENCH

The No. 6 combination ratchet socket wrench set shown in the accompanying illustration is a product of the Walden Mfg. Co., Worcester, Mass. Referring to this illustration, it will be seen that the equipment consists of a 9-inch ratchet

The No. 6 Walden Combination Socket Wrench

wrench, an extension bar, a universal joint and sixteen assorted sizes of sockets, including a long spark plug socket. The sockets cover a range of sizes from ½ to 1¼ inch and fit cap-screws from 5/16 to 1 inch, U. S. S. nuts from ¼ to ¾ inch, and A. L. A. M. nuts from 5/16 to ⅞ inch. The wrench is packed in a fiber box and weighs five pounds.

A No. 4 combination wrench set of similar design is made by this company which consists of the wrench, a universal joint, an extension bar and a set of eight sockets. A No. 10 set is also made which includes three wrenches, 5, 9 and 12 inches in length; an extension bar; a universal joint; and a set of thirty-one sockets. These wrenches are primarily intended for the use of automobile owners and mechanics employed in garages, but the same style of wrench could be used to advantage in many machine and assembling shops. The different combinations that are possible will be evident from the illustration.

ACME SEMI-AUTOMATIC NUT TAPPERS

To meet the demand for a nut tapping machine of simple construction, capable of turning out a large production, the Acme Machinery Co., Cleveland, Ohio, maker of forging, nut making and threading machinery, has brought out a line of semi-automatic nut tapping machines, the 1-inch size of which is shown in Fig. 1. The machine illustrated has a capacity for tapping either square or hexagon nuts from ⅝ to 1 inch (this is the diameter of the tap used). It is possible to obtain a much greater output with this machine than with the older types of six-spindle machines, the increase in production ranging from 50 to 100 per cent.

Each tap-holding spindle is operated independently. It is counterweighted to prevent breakage of taps and is provided

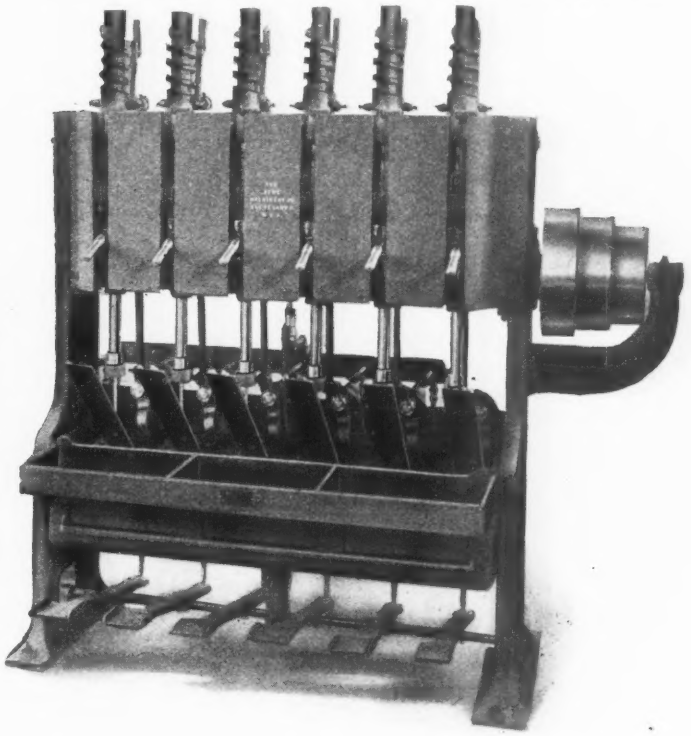


Fig. 1. One-inch Size of Acme Semi-automatic Nut Tapping Machine

with an automatic lifting device consisting of a worm and auxiliary mechanism. By means of this device the tap is lifted after one nut has been tapped, allowing the next nut to be fed in automatically from the chute to the nut holder. The operation of the feeding mechanism of the machine can be seen more clearly by referring to Figs. 2 and 3. As the tap passes through the nut, the worm shown at the top of the spindle drops, and in so doing comes in contact with a bronze washer or collar. This collar, through a bell-crank arrangement of levers, pushes a shoe into contact with the threads of the worm, whereupon the latter rises and lifts up the tap and the nuts on it clear of the nut holder, allowing another nut to be fed in. The nut is fed in by a feeding finger, operated from a rod at the rear of the machine, through a system of levers which come into action as the spindle is lifted.

Fig. 2 shows the tap spindle in the "up" position and the feeding finger pushing another nut into the nut holder. Fig. 3 shows the tap just as it has passed through the nut being tapped. The cycle of operations outlined is repeated until

the shank of the tap is filled with nuts, whereupon the tapping spindle ceases to operate, owing to the filled tap preventing the worm from contacting with the bronze collar previously mentioned. As soon as the tapping spindle ceases working

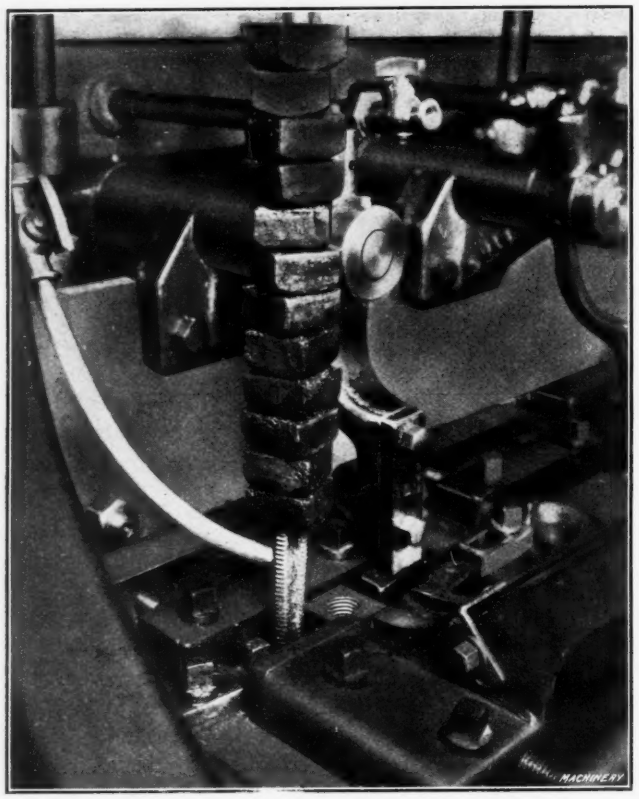


Fig. 2. Close View showing Tap raised and Nut being fed in

the operator removes the filled tap by depressing the foot-lever. This lifts the spindle, and consequently the tap, clear of the nut holder, enabling the tap to be easily removed; quick-acting ring chucks are provided so that this can be done while the spindle is rotating. The nuts are then slipped off the shank of the tap, the latter is replaced in the quick-acting chuck, and as the operator removes his foot from the foot-lever the machine begins operating again.

The worm cannot drop until the threads on the tap have cleared the nut, so that if the trips on the machine are properly set it is impossible for two nuts to be on the threaded portion of the tap at the same time. The nuts are fed to the machine through a chute, which can be adjusted to suit various sizes of nuts within the range of the machine, as can also the nut holder. A rotary oil pump is furnished so that a copious supply of cooling liquid is supplied to the taps at all times, keeping them cool and clean and allowing the maximum speed to be obtained. Movable chip pans with screen bottoms are provided which allow the oil to drain from the chips and permit the chips to be easily removed.

This type of nut tapper is also built in ½-inch size. The regular equipment furnished with the machines consists of a rotary pump, a countershaft, the necessary wrenches, a chip pan, and six quick-acting ring sockets of any size within the capacity of the machine. This equipment can be changed, however, to suit individual requirements.

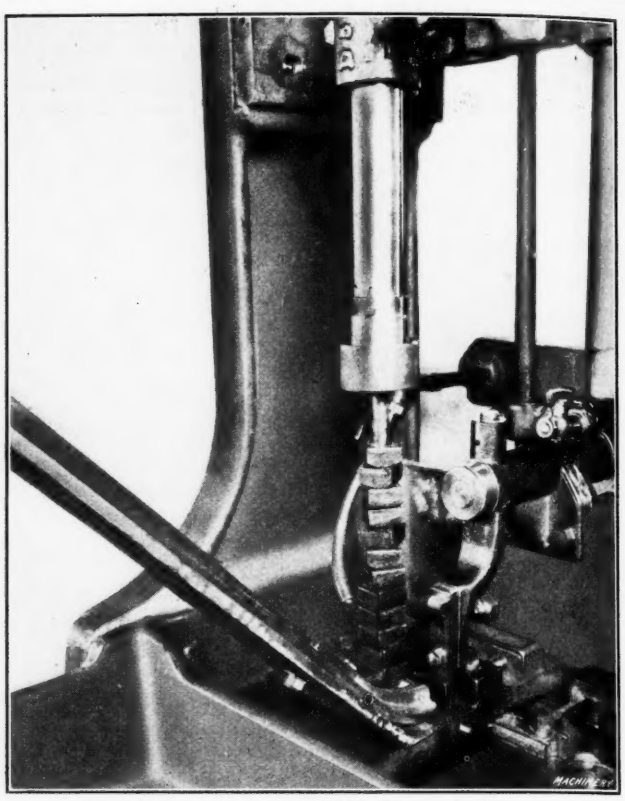
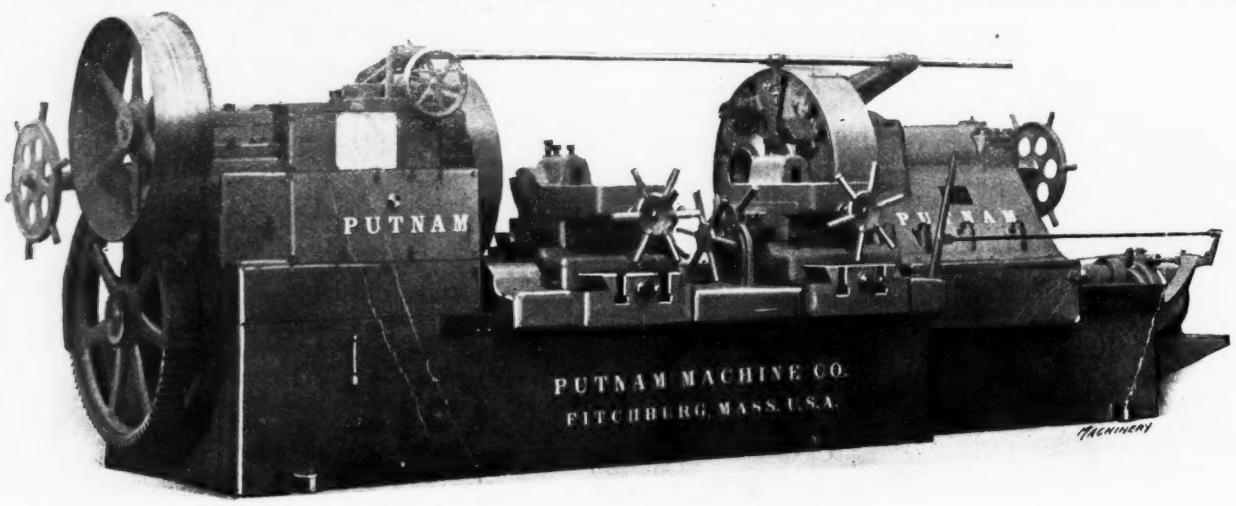


Fig. 3. Close View showing Tap in Action

PUTNAM COACH WHEEL LATHE

In the May, 1913, issue of MACHINERY a 42-inch coach wheel lathe manufactured by the Putnam Machine Co., Fitchburg, Mass., was illustrated and described. Since that time the design of this lathe has been improved in several ways, which add materially to its efficiency of operation. These improvements will be described in the following:

An improved form of combination tool-slide which has been applied to the lathe reduces the work of turning a pair of tires to two operations without the necessity of changing cutting tools except in the case of tool failure or breakage. This tool-slide is self-contained and is not dependent upon compressed air or manual labor for its function of holding the cutting tools. In case of tool failure, the arrangement is such that a change of tools can usually be effected while the companion tool is cutting and without loss of time. The



Putnam Coach Wheel Lathe of Improved Design

divided nut on both the transverse and longitudinal feed screws in the tool blocks provides for taking up any backlash which may develop. The tool-slide has one roughing and one full width forming tool mounted side by side, each of which is readily detachable for the insertion of a fresh tool. The single screw tool clamp is positive in action and holds the cutting tools rigidly under all operating conditions. It is only necessary to tighten a single screw to clamp the tools. The binder arm is of steel and hardened on the contact point. The tools are clamped down onto the hardened steel plates having corrugated surfaces.

Another improvement consists of the provision of power longitudinal movement of the tailstock in connection with an automatic tailstock clamping device. The tailstock motor is started up under no load, the control being entirely mechanical. The tailstock is run forward until taper surfaces engage with corresponding surfaces on the bases of the tool blocks to automatically stop the tailstock and clamp it to the bed. The motor is then released by a friction relief. Reversal of the tailstock motor releases the clamping device and allows the tailstock to be run back away from the headstock. When the tailstock is clamped the downward force of the work against the cutting tool and the force tending to lift the tailstock up off the bed counteract each other. This result is obtained by having the tool block overlap a projection on the tailstock, a similar construction being used between the tool block and headstock.

NIAGARA BOTTOM FLANGING MACHINE

The accompanying illustration shows a bottom flanging machine recently built by the Niagara Machine & Tool Works, Buffalo, N. Y. This machine is intended for turning out bottoms and tops for barrels, tanks, etc., and it is particularly useful where it is required to produce heads of different diameters, as it would often be out of the question to make dies, owing to the limited number of pieces to be formed. Other shaped flanges besides the square ones shown in Fig. 2 may be formed by substituting the required shape of rolls. The machine may also be used for cutting circular disks and for slitting sheets, in which case rotary cutters are substituted in place of the flanging rolls.

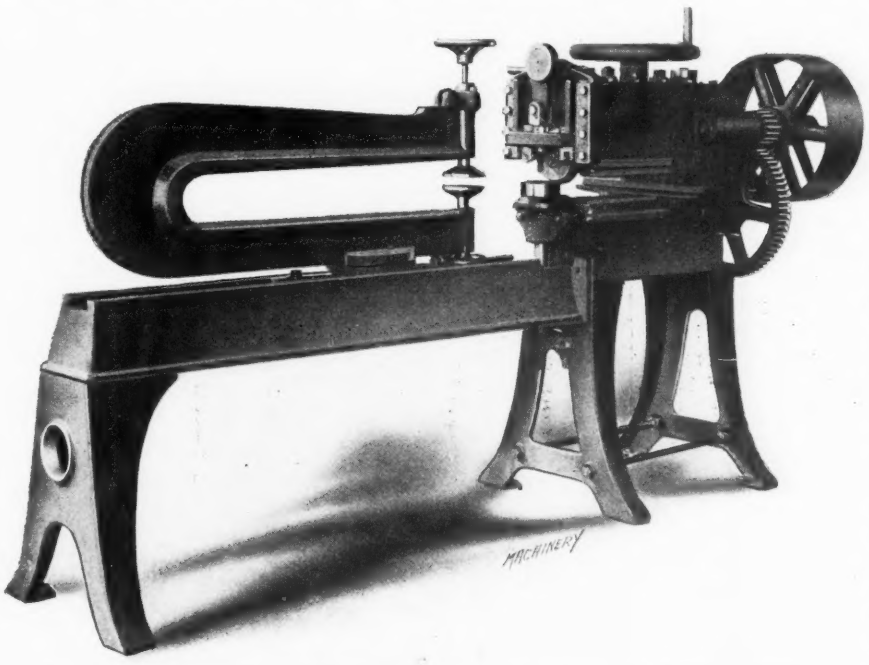


Fig. 1. Niagara Machine for forming Flanged Tops and Bottoms for Barrels or Tanks

The machine is single back-geared and provided with tight and loose pulleys. The main gear is mounted on the lower shaft, from which power is transmitted to the upper shaft through a compensating connecting gear. The lower flanging roll is mounted on a vertical shaft that is driven from the main shaft through bevel gears. The upper shaft can be adjusted laterally to allow for variation in the thickness of the material. For this purpose there is an eccentric segment lever located at the front of the machine within easy reach of the operator. The upper shaft may be raised and lowered, but always kept in horizontal alignment by means of an arrangement of screws and gears operated by a handwheel located at the top of the machine.

In order to prevent the metal from becoming distorted during the flanging operation, two hold-down rolls are provided on the slide in front of the upper flanging roll; and to facilitate the removal of flanged disks, the hold-down rolls can be quickly raised and lowered by an eccentric lever. The machine shown in Fig. 1 will flange disks from 14 to 60 inches in diameter. For material up to No. 10 gage soft sheet steel, the maximum height of the flange that can be produced is 1½ inch. The machine will cut metal as heavy as No. 8 gage and disks can be cut ranging from 8 to 53 inches in diameter.

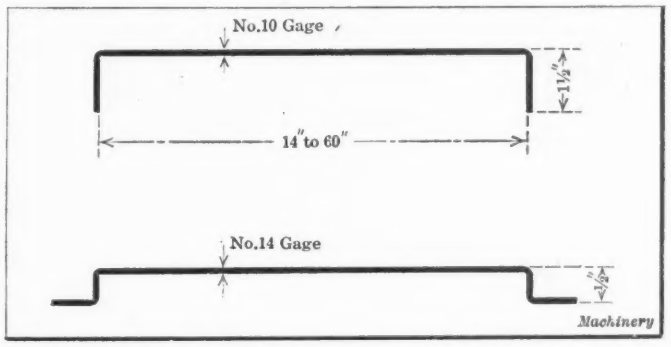


Fig. 2. Range of the Machine in Nos. 10 and 14 Gage Soft Steel

LANDIS PLAIN GRINDING MACHINE

The accompanying views are of a large motor-driven plain grinding machine just completed by the Landis Tool Co., Waynesboro, Pa. This machine has a capacity for work 30 inches in diameter and 20 feet in length. As will be seen, it is driven by three motors; one for driving the grinding wheel, one for revolving the work and traversing the grinding wheel, and one for driving the water pump. The work and traversing motor drives the gear box at the end of the machine which is arranged with a clutch mechanism so that the drives can be started and stopped independently, or together independent of the motor. The motor runs at a constant speed and the speed changes of both the work and wheel traverse are made by an arrangement of gear shifts and clutches, all of which are operated from one position at the front of the machine. There are sixteen different work speeds, ranging from 2 to 45 revolutions per minute; and ten changes of wheel traverse speed, ranging from 2½ to 84 inches per minute.

The grinding wheel is driven by a variable speed motor, the speed of which is controlled by the electric apparatus shown mounted upon the main wheel carriage. The standard size wheel for this machine is 30 inches in diameter and has a wearing range of 8 inches on the diameter, the electric controller being arranged to give the proper cutting or peripheral speed with the wheel at any size within its range of wear. As will be seen by the rear view, the grinding wheel motor is mounted upon a separate carriage which travels on a track formed on the base of the machine. The wheel and motor carriages are entirely independent except for an arm connection for propelling the motor carriage with the traversing movement of the wheel carriage. The motor carriage is mounted on large rollers which are fitted with ball bearings. The track surfaces upon which this carriage travels are protected by metal guards. The electric current is transmitted to the wheel motor through sliding contact shoes and feed wires located along the body of the machine.

These wires are also protected by a shed-formed metal guard to prevent anything falling on them from directly above.

The grinding wheel slide, for feeding the wheel to and from the work, is arranged with a rapid mechanical feed mechanism which is operated by the vertical lever located between the feed handwheel and the motor controller as shown in Fig. 1. This is for the purpose of moving the wheel away from the work quickly when changing from piece to piece, or from one size to another, in case various diameters are being ground on the same piece and for feeding the wheel in quickly to the grinding position. The transverse movement of the wheel is in the same direction as the movement of the operating lever; to feed to the work the lever is pulled in the same direction and *vice versa*. In addition to this, there is the usual hand feed, as well as automatic feed for feeding the wheel at the reversing points.

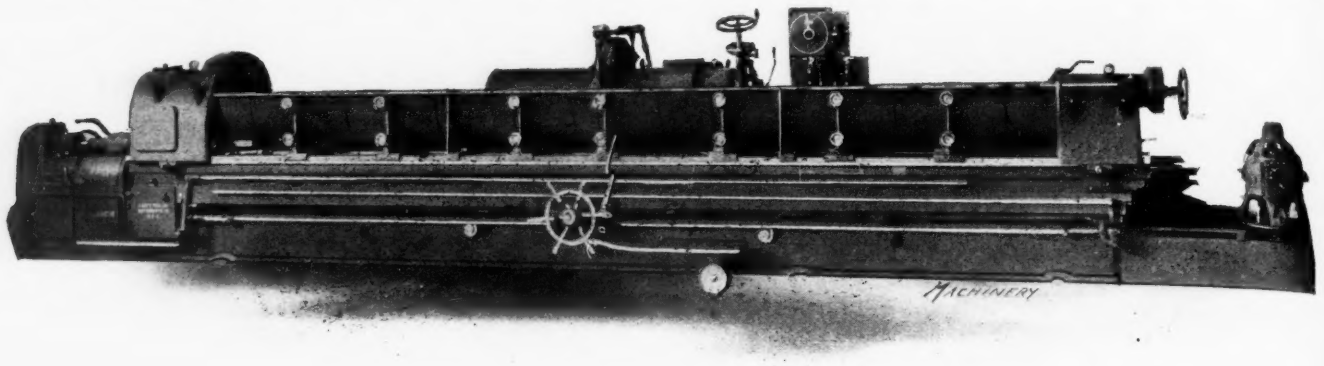


Fig. 1. Front View of Landis Motor-driven Plain Grinding Machine

The grinding wheel motor is controlled by an automatic motor starter and field rheostat with rheostat relay. This makes a very efficient arrangement, as the controller can be set to give the wheel the proper peripheral speed for any size of diameter within its wearing range, and the motor is then operated by an ordinary knife switch. This arrangement gives a positive control of operation and with the automatic starter the speed picks up gradually after the starting switch has been thrown into contact. Another feature of the construction of this machine is that all bearings of spindles which run continuously while the machine is in operation are made of bronze, and the spindles are of hardened and heat-treated steel.

The starting box of the water pump motor is mounted directly upon the motor itself, which places it in a very convenient position for the operator. The starter for the work-drive and wheel-traverse motor is not shown, as this is mounted to meet existing requirements when the machine is installed. This machine is intended for grinding a line of large shaft work, the largest piece to be handled occupying the full distance between centers, and the diameters will range up to 24 inches. It is strictly a manufacturing grinder and is particularly well suited for such work as engine crankshafts, steam turbine shafts, armature shafts and heavy roll work. This machine is also built for 40 inches swing when desired.

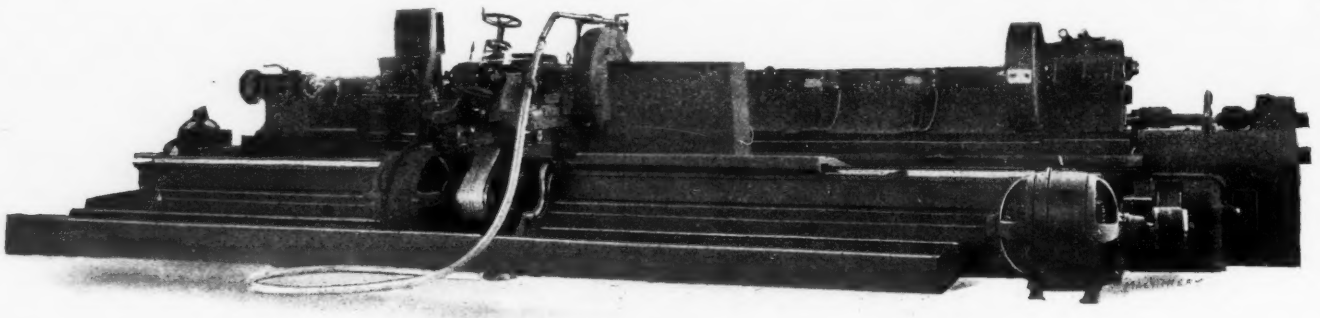


Fig. 2. Rear View of Landis Grinding Machine shown in Fig. 1

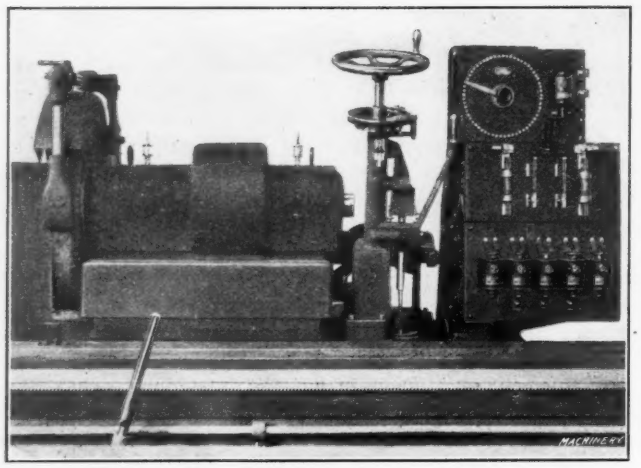


Fig. 3. Electrical Apparatus for controlling Grinding Wheel Motor

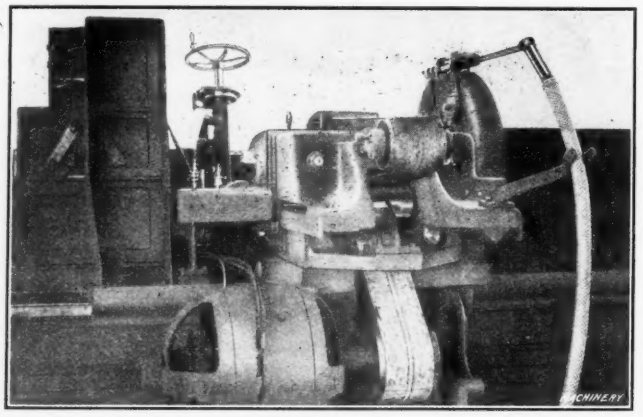


Fig. 4. Rear View showing Wheel Drive and Pump Connection

NORTON PLAIN GRINDING MACHINE

The Norton Grinding Co., Worcester, Mass., is now building the small machine for grinding cylindrical work shown in Figs. 1, 2 and 3. It is made to swing 3 inches in diameter in order to afford room for suitable steadyrests for supporting work ranging from ⅛ inch to 1 inch in diameter and up to

18 inches in length. The machine is particularly adapted for handling work from ⅛ to ½ inch in diameter and is designed for finishing cuts where there is not more than from 0.004 to 0.008 inch of stock to be removed from the diameter of the work. It is especially useful for grinding small twist drills, tool work, and the parts of cream separators, sewing machines, electrical apparatus, phonographs, roller bearings, and similar classes of work.

The machine is self contained, no overhead works being

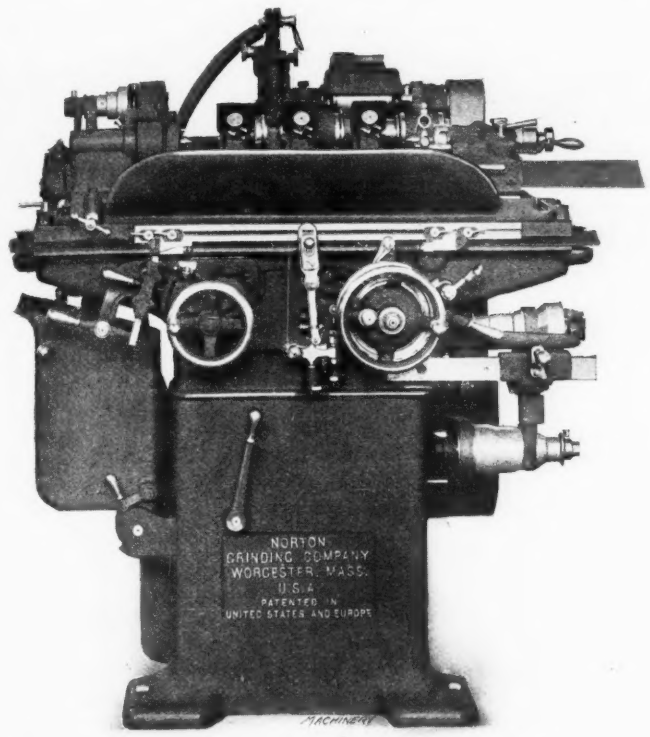


Fig. 1. Front View of Norton 3 by 18-inch Plain Grinding Machine

required. The drive is by a belt either from above or below, or by a motor placed on the floor at the back of the machine. The table reverse is pneumatically cushioned, making it possible to operate the table at a maximum speed of 27 feet per minute. Eight table speeds are provided, the slow-

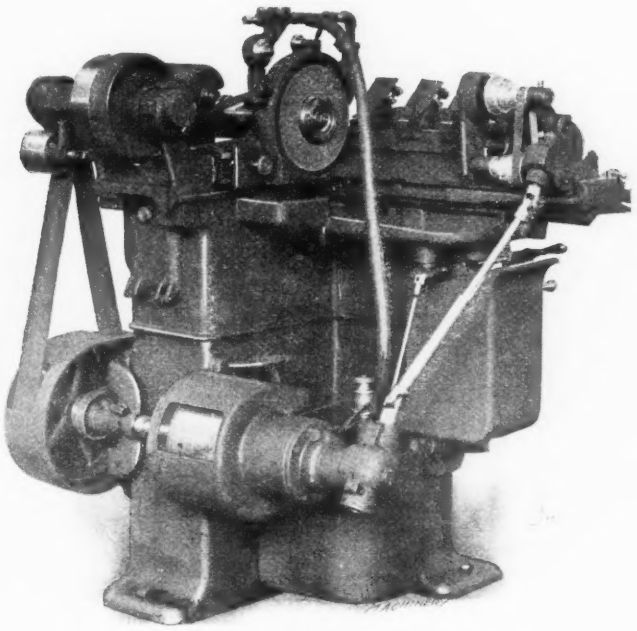


Fig. 2. Rear View of Grinding Machine shown in Fig. 1

est of which is 17 inches per minute. The automatic and hand cross-feed, while of entirely new design, sacrifice nothing in the matter of accuracy in sizing the work. The control of the revolution of the work and of the table traverse is unusual, in that while either can be started separately or both simultaneously, the stopping of the work always stops the table and the table cannot be started unless the work is revolving. Stopping the table connects the handwheel for moving the table by hand, and this handwheel is disconnected when the table is started. The footstock covers the dovetail ways on which it slides and protects them from damage. The steadyrests are especially designed for small work; they are provided with micrometer stops and arranged for quick handling. Three universal steadyrests are furnished with the machine and also a set of hardened steel work shoes for one diameter of work. These shoes are designed to give a quick change from one size of work to another; they provide convenient means for making adjustments and rigid support for long work of small diameter. The work shoes are of steel, hardened and ground.

Four work speeds are provided, ranging from 160 to 640 revolutions per minute. The wheel spindle is a chrome-nickel steel forging carefully heat-treated. The shafts are self-oiled and the loose pulley runs on a self-oiling roller bearing. The footstock spindle, in common with a number of other parts of the machine subjected to wear, is hardened to insure satisfactory wearing properties. The pump provides an ample supply of lubricant to the wheel and work, and the settling tank is con-

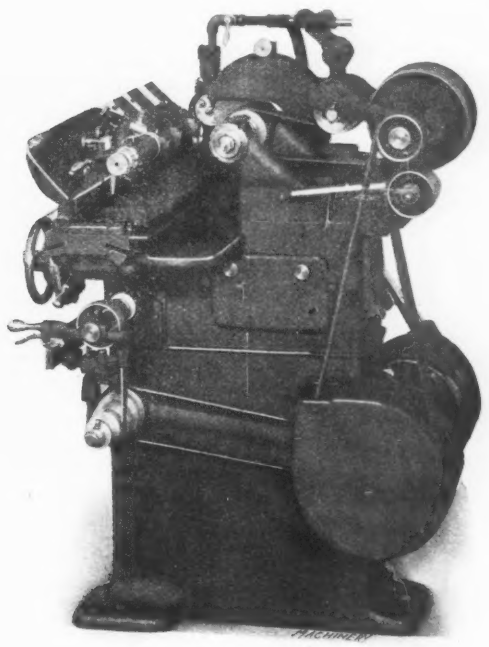


Fig. 3. Right-hand End of Norton Plain Grinding Machine

veniently arranged for cleaning. The machine carries wheels 10 inches in diameter by ¾ inch face width, and tapers up to 2 inches per foot can be ground.

The regular equipment provided with the machine includes two wheels, three complete universal steadyrests, three work shoes for one size of work, a diamond for dressing the grinding wheel, a center grinding attachment and a suitable equipment of wrenches. All belts are furnished in place ready for use with the exception of the main driving belt. The weight of the machine is about 1950 pounds.

WILLEY ENGINE LATHE

In bringing out the lathe illustrated in Figs. 1 and 2, the purpose of the Willey Machine Co., Jeffersonville, Ind., was to meet the demand for a small machine equipped with a simple and reliable motor drive. When desired, this lathe can also be driven by a belt from the countershaft. It is a standard lathe with a standard motor and a standard cone drive from the motor to the lathe.

The bed is made narrow under the headstock so that the belt can pass down to a cone pulley on the countershaft. The countershaft is provided with means for vertical adjustment to take up slack in the endless belt. The motor is started and stopped by a handle near the headstock. There is one large

vee at the front of the bed and a flat way at the back of the bed upon which the carriage and tailstock are mounted. The motor regularly used in this lathe develops ¼ horsepower and is found to be ample for the requirements of the average shop. A ½-horsepower motor is required to pull the lathe to the limit of its capacity. The cone pulleys take a belt 1½ inch in width. The diameter of the front spindle bearing is 1⅜ inch,

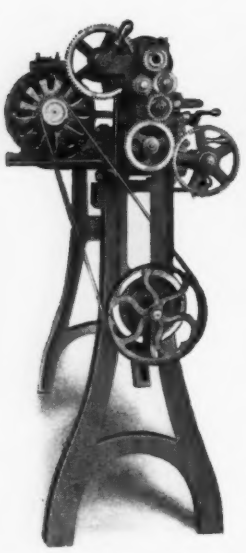


Fig. 1. End View of Willey Lathe

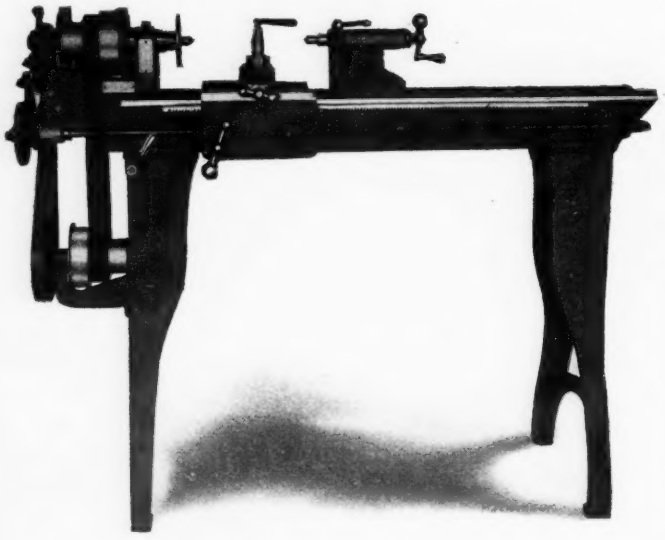


Fig. 2. Front View of Willey Engine Lathe

and the diameter of the back spindle bearing 1⅛ inch. The lead-screw is ⅞ inch in diameter, and the lathe swings 10¼ inches over the bed and 6 inches over the carriage. The weight of the machine is about 500 pounds.

GREAVES-KLUSMAN GEARED HEAD LATHE

The accompanying illustrations show a 17-inch quick-change geared-head lathe with single pulley drive, which is a recent product of Greaves, Klusman & Co., Cincinnati, Ohio. In the design of this lathe the use of frictions in the geared head has been entirely eliminated, all speed changes being obtained through sliding gears. The arrangement is similar to the sliding gear transmission used on automobiles; it consists of few parts, and thorough tests have demonstrated its durability. In the automobile sliding gear transmission the operation of two levers is required for throwing out the friction clutch and obtaining speed changes. On this lathe a single vertical lever on the headstock operates the speed changes and engages the friction clutch driving pulley. Before any speed changes can be obtained it is necessary for the operator to disengage the friction clutch. This relieves the gears of all strain and allows them to slide freely and without shock or jar.

Ten spindle speeds are provided, any of which can be obtained instantly without stopping the lathe and while the tool is cutting. A single in or out movement of the vertical lever operates the friction clutch on the driving pulley to start or stop the lathe, and by moving this lever to the right or left into notches which are plainly marked, any desired spindle speed can be instantly obtained. The action of this vertical lever is self-locking, and in connection with the notched segment and direct reading index plate, it forms a most convenient method of control.

The horizontal lever at the top of the headstock provides for driving the spindle either direct or through the back-gears. By placing this lever in the neutral position, the spindle is disengaged to provide for revolving it by hand. Power is transmitted through heat-treated steel gears which are driven by a single friction-clutch pulley which delivers ample power to the cutting tool under all conditions. The spindle is driven at a point close to the front bearing, thus reducing vibration and torsional strain on the spindle to a minimum. The arrangement of the gearing is such that only those gears required for any one speed can be engaged and there are no idle revolving gears to add to the frictional load.

An interior view of the headstock is shown in Fig. 3. The initial driving shaft transmits power through gears to a driven shaft having a cone of five gears. Power is then transmitted to a second driven shaft having a cone of three sliding gears which engage with three of the cone gears on the first driven shaft. On one end of the three sliding gears there is a positive stepped clutch and by sliding these three cone gears along on the shaft they connect with a spring tensioned cone of two gears with a positive stepped clutch. When in this position, the five sliding cone gears are connected and power is transmitted to the fourth cone gear on the second driven shaft. By sliding these five gears still further along, the fifth cone gear on the second shaft is engaged. This makes

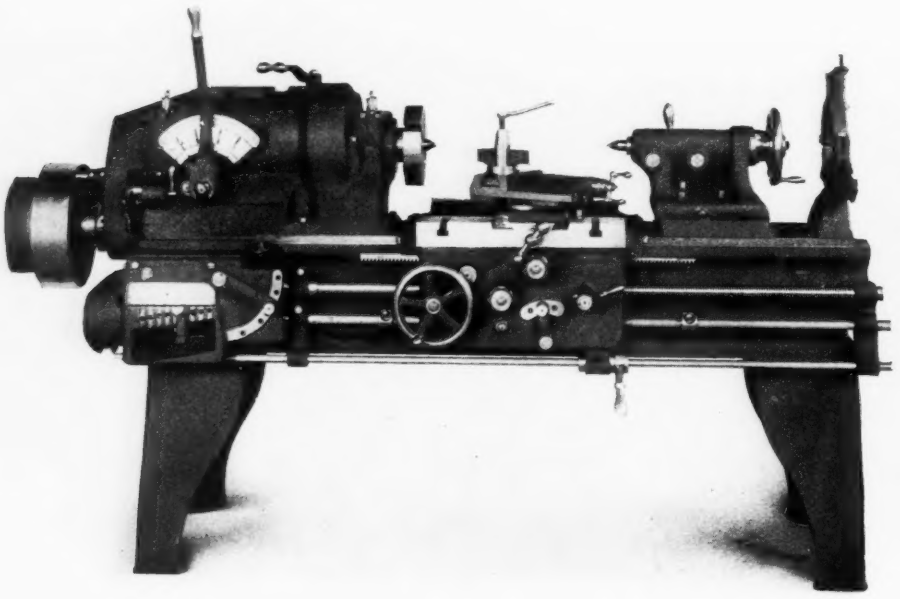


Fig. 1. Greaves-Klusman 17-inch Quick-change Geared-head Lathe with Single Pulley Drive

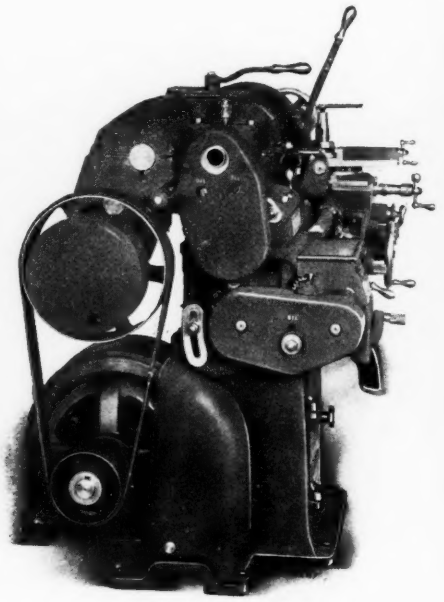


Fig. 2. End View of Greaves-Klusman Lathe with Motor Drive

five changes of speed direct to the spindle, and by engaging the back-gears, five additional speed changes are available, giving a total of ten speeds, all of which are controlled by the vertical lever. Both cone shafts are mounted in anti-friction ball bearings at both ends and in the center. Two of these ball bearings on the second driven shaft are placed close to the face wheel pinion to carry the heavy load that is imposed upon this pinion.

The headstock is of box section with the sides extending up to the center line of the spindle. Heavy internal braces extend both lengthwise and crosswise and make an exceptionally rigid construction. The headstock forms an oil reser-

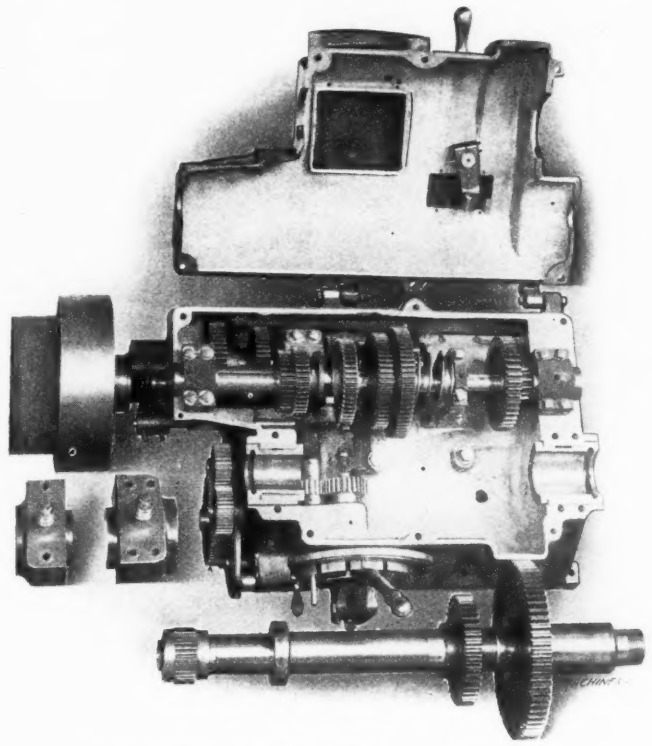


Fig. 3. Interior of Headstock of Greaves-Klusman Lathe

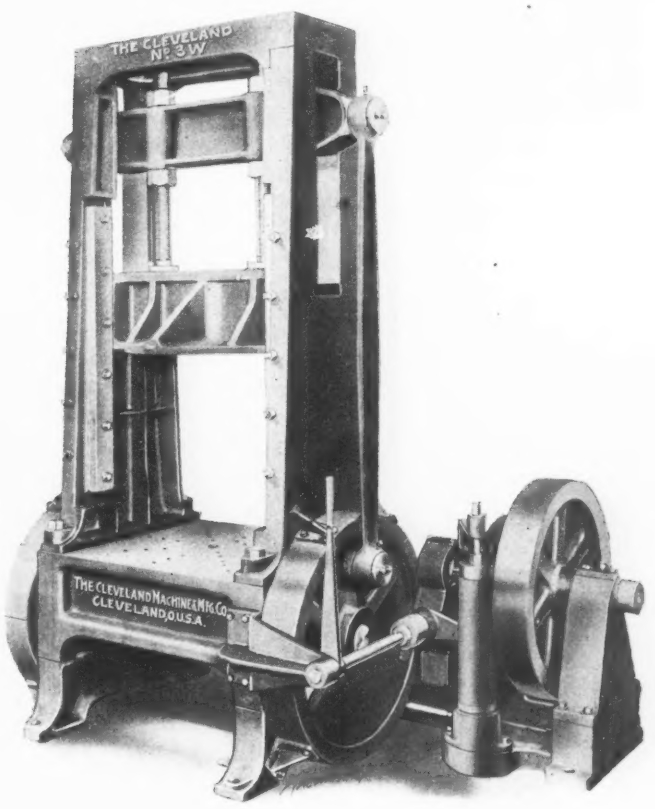
voir which keeps the gearing well oiled, increases its efficiency and reduces wear. All of the mechanism is located inside the headstock and the top of the headstock is hinged to afford access to the gearing and other parts. The spindle is of chrome-nickel steel with the front bearing hardened and runs in phosphor-bronze boxes. The spindle bearings are lubricated by sight-feed oilers. The end thrust is carried by alternate hardened steel and bronze thrust washers. A phosphor-bronze flanged sleeve is secured to the headstock and the friction driving pulley runs on this sleeve, thus relieving the driving shaft of all belt pull. The driving pulley is enclosed at the outer end and the hub is provided with an oil well, the construction being such that the oil passes through a felt pad which filters it before it reaches the bearing. In addition to the vertical lever on the headstock for engaging the friction clutch pulley, connection is made direct to the apron so that the operator can start or stop the lathe without leaving the working position. For this purpose a lever is attached to the lower left-hand end of the apron, as will be seen in Fig. 1.

With the constant speed single pulley drive, the lathe can be belted direct from the lineshaft, or a single speed tight and loose pulley countershaft or a double friction pulley countershaft may be used. Fig. 2 shows the end view of a lathe equipped with individual motor drive which requires no additional floor space. The motor is attached to an oscillating plate inside the cabinet leg, this plate being pivoted to allow the motor to be raised and lowered. This affords means of obtaining the desired belt tension at all times, and as the motor is located close to the floor, it does not have any tendency to produce vibration in the lathe. If desired, direct-connected motor drive may be employed by substituting a friction gear for the friction drive pulley and mounting the motor upon the rear of the cabinet lathe. Any standard make of direct- or alternating-current, constant- or variable-speed motor may be used. All of the features of Greaves-Klusman lathes are included in this machine, among which may be mentioned the heavily reinforced bed; the elimination of tool overhang when turning work of the largest diameters; the double clamp, single-acting tailstock; a double walled apron with double supports for all studs and shafts; and the feed-rod supported at each end of the apron with automatic stop in both directions.

CLEVELAND WIRING AND FORMING PRESS

The long stroke wiring and forming press illustrated herewith is a recent product of the Cleveland Machine & Mfg. Co., Cleveland, Ohio. This machine is intended for deep forming operations on light sheet metal parts and for wiring the edge of wash tubs, water pails, ash cans and similar articles. The bed area is 32 inches square, and the stroke of the slide is 20 inches. In order to secure a rigid frame and proper gib construction, the uprights or housings are made unusually deep from front to back and they are heavily ribbed to obtain the desired stiffness. Lugs on the back of the gibs fit into cored pockets in the housings and take the pressure of the adjusting screws. The construction gives an unusually good bearing for the slide, and at the same time permits the slide to be removed from the machine without taking down the housings.

The machine is double-geared, the ratio of the gearing being



Cleveland Wiring and Forming Press

10 to 1, and it is belt driven through the flywheel which acts as a pulley. A cone friction clutch mounted in the flywheel is operated by a cam on the main shaft under the bed, which automatically releases the clutch on the up stroke and applies a brake to the driving shaft. Pressure on the foot treadle releases the brake, and the clutch is thrown in by a weight which is cushioned in a dash-pot. For setting dies, the automatic arrangement of the clutch can be disengaged by loosening a nut on the lever shaft and the machine can then be operated by means of the hand lever shown. The total weight of this wiring and forming press is 7000 pounds.

CLEVELAND 7 3/4 INCH AUTOMATIC SCREW MACHINE

The following description will give some of the most interesting facts concerning the largest and most powerful full automatic screw machine that has ever been built. This machine, a front view of which is shown in Fig. 1, is the product of the Cleveland Automatic Machine Co., Cleveland, Ohio; it will handle round rough bar stock up to 7¾ inches and varying 1/16 inch in diameter anywhere along the bar. A ten-foot bar of 7¾-inch round stock weighing 1584 pounds is handled with the same ease, and fed out to the same exactness, as regards length, as a two-inch bar. This machine represents an unusual development in automatic machinery for producing parts from bar stock; with suitable magazine attachments it will also handle castings and forgings.

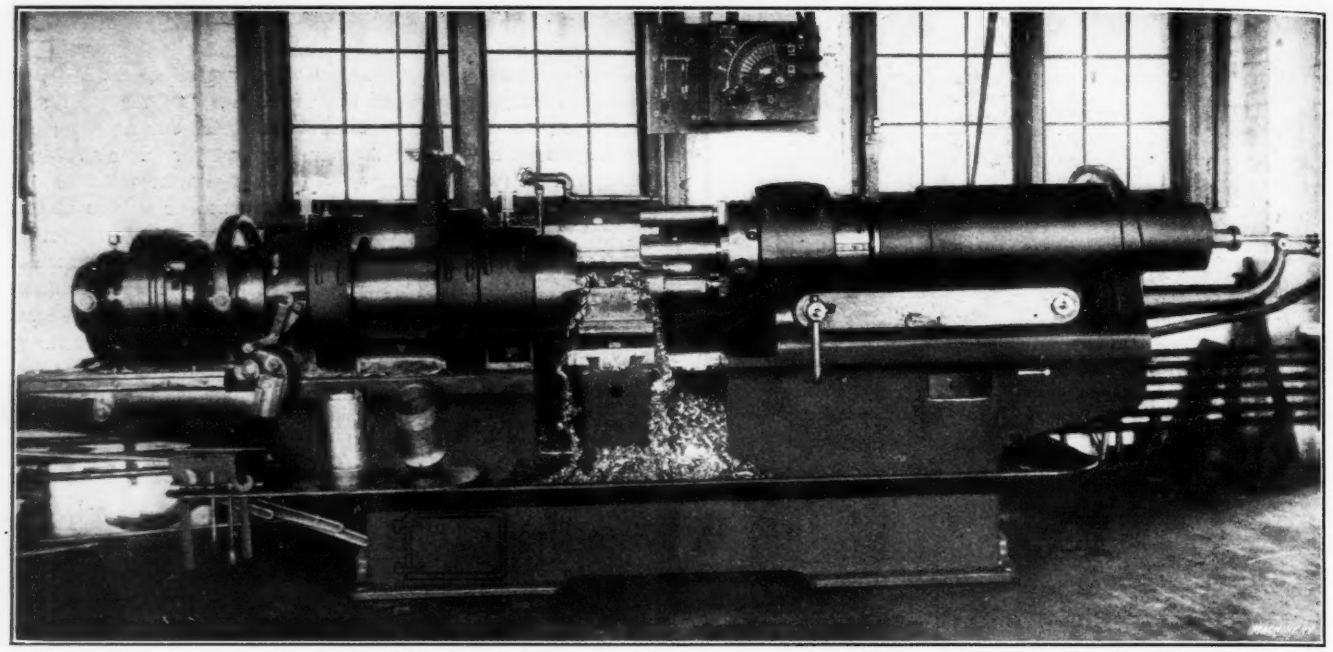


Fig. 1. Front View of 7¾-inch Cleveland Automatic Screw Machine (Gear Guards removed)

The Head and Spindle

Some idea of the massiveness of the machine will be gained from a study of the head. The work-spindle, made from a semi-steel casting, is 58⅞ inches long, has an average diameter of 12¼ inches, and weighs 1100 pounds. The bronze bearings of the work-spindle have a total bearing surface of 630 square inches. The chucking pressure is approximately 1500 pounds. In order to operate the chuck by hand when setting up the machine, it was necessary to provide a powerful toggle-joint device, which the operator brings into action by a long lever, as shown in Fig. 3. This toggle is disconnected from the chuck opening and closing mechanism, when the chuck is operated by power. The greatest length of stock feed is 16⅝ inches, and this mechanism is operated by a cam on the rear shaft, the variations in length of feed being effected by adjusting the feed slide along the bed extension provided for that purpose. The chuck is closed and opened by another cam on the rear shaft. The hood on the nose of the spindle which envelops the work-holding chuck is 15⅝ inches in diameter, and the spring chucks used are of the "pad" type; that is, those parts of the chuck which grip the bar are in the form of pads held by screws in the chuck proper.

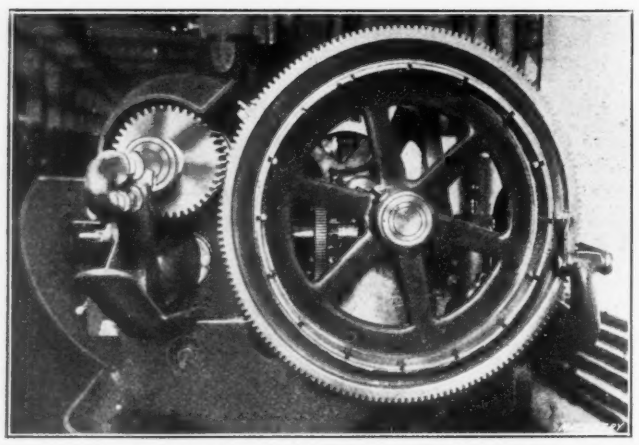


Fig. 2. End View of Cleveland Automatic, showing Regulating Drum and Auxiliary Mechanism

Turret and Turret Head

The turret, which is of the barrel or drum type, is 18⅜ inches long by 14¼ inches diameter, and weighs 555 pounds. It is provided with four 2¼-inch holes for holding the end-working tools. The turret head has a longitudinal adjustment along the bed of 7¼ inches. The shortest distance between the face of the chuck and the end of the turret, with the turret advanced is 10 inches, whereas the greatest distance between these two members, with the turret advanced, is 17¼ inches. The greatest length of bar that can be turned is 9 inches. The turret is advanced at the proper speed by means of a regulating drum (see Fig. 2) through a friction feed, differential and worm-gearing. The cam which controls the forward advance of the turret is held on the turret-operating drum, and rotates against a roll which is rigidly supported on the machine bed. This roll is presented at a slight angle to the line of pressure on the turret tools, which not only tends to increase rigidity, but enables much heavier feeds to be taken as well. Variation in the feed given to the tools is accomplished by shifting the positions of strip cams on the large regulating drum, this action changing the position of the friction roll between the friction disks. When indexing the turret, bringing the tools up to the work, etc., the turret and all the automatic movements are operated at fast speed, being driven direct and not through the friction disks.

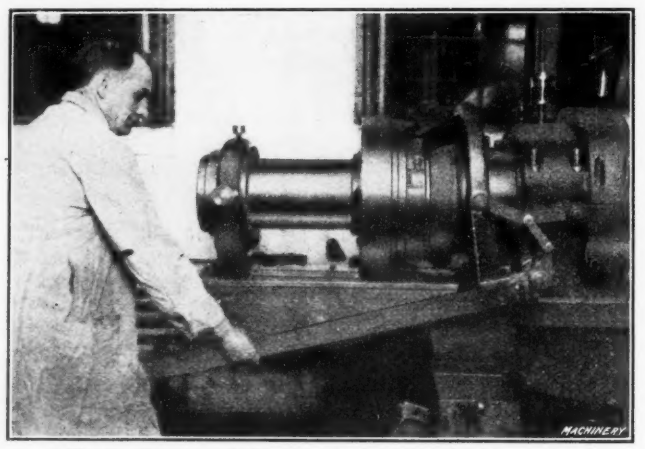


Fig. 3. Operator closing the Chuck by Hand when setting up—Chucking Pressure 1500 Pounds

Cross-slides and Other Details

The cross-slides comprise one solid casting 37⅞ inches long by 11⅝ inches wide, weighing 410 pounds. This slide, which generally carries a forming tool on the front and a cut-off

Fig. 4. An Example which shows to a Remarkable Extent what this Machine will do. It removed 105 Pounds of Chips to form a Spring Collet in 48 Minutes

blade at the rear, has a travel of 13¼ inches and is operated through a bell-crank lever receiving power from cams on a drum held on the rear shaft. The feed of the cross-slide tools is also controlled, in conjunction with the cams on the drum,

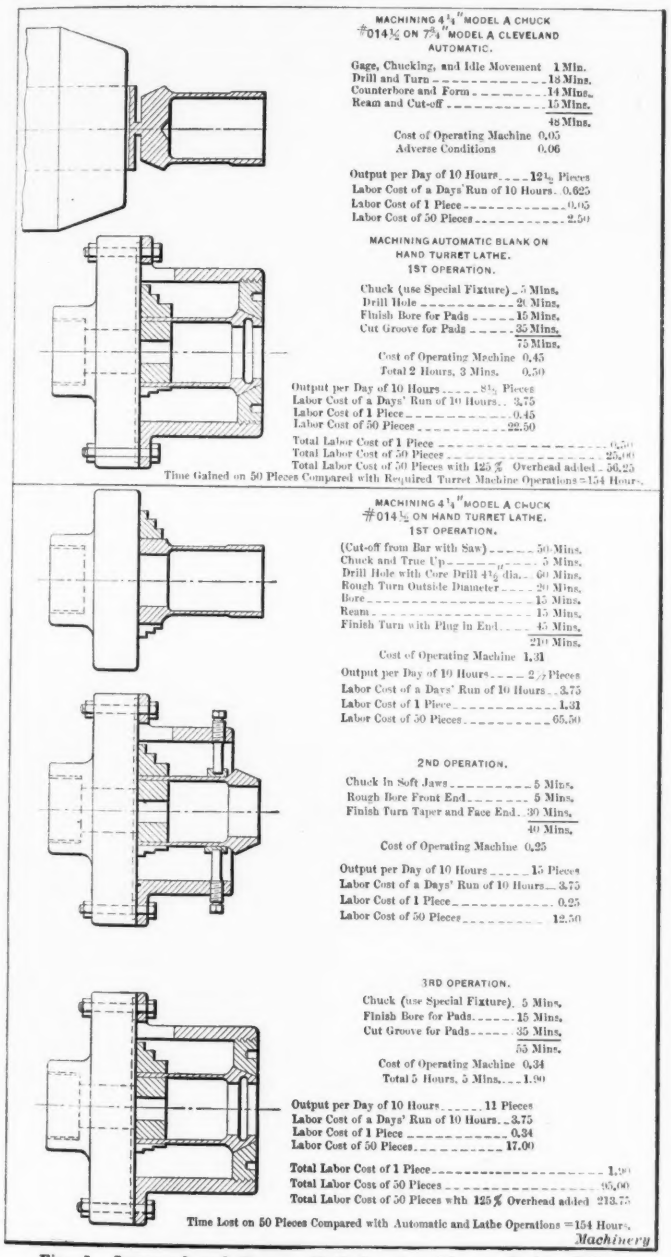

MACHINING 4¼" MODEL A CHUCK #014½ ON 7¾" MODEL A CLEVELAND AUTOMATIC.
Gage, Chucking, and Idle Movement 1 Min.
Drill and Turn 18 Mins.
Counterbore and Form 14 Mins.
Ream and Cut-off 15 Mins.
48 Mins.
Cost of Operating Machine 0.05
Adverse Conditions 0.06
Output per Day of 10 Hours 12½ Pieces
Labor Cost of a Days' Run of 10 Hours 0.625
Labor Cost of 1 Piece 0.05
Labor Cost of 50 Pieces 2.50
MACHINING AUTOMATIC BLANK ON HAND TURRET LATHE. 1ST OPERATION.
Chuck (use Special Fixture) 5 Mins.
Drill Hole 20 Mins.
Finish Bore for Pads 15 Mins.
Cut Groove for Pads 35 Mins.
75 Mins.
Cost of Operating Machine 0.45
Total 2 Hours, 3 Mins. 0.50
Output per Day of 10 Hours 8½ Pieces
Labor Cost of a Days' Run of 10 Hours 3.75
Labor Cost of 1 Piece 0.45
Labor Cost of 50 Pieces 22.50
Total Labor Cost of 1 Piece 0.50
Total Labor Cost of 50 Pieces 25.00
Total Labor Cost of 50 Pieces with 125% Overhead added 56.25
Time Gained on 50 Pieces Compared with Required Turret Machine Operations = 154 Hours.
MACHINING 4¼" MODEL A CHUCK #014½ ON HAND TURRET LATHE. 1ST OPERATION.
(Cut-off from Bar with Saw) 50 Mins.
Chuck and True Up 5 Mins.
Drill Hole with Core Drill 4⅛ dia. 60 Mins.
Rough Turn Outside Diameter 20 Mins.
Bore 15 Mins.
Ream 15 Mins.
Finish Turn with Plug in End 45 Mins.
210 Mins.
Cost of Operating Machine 1.31
Output per Day of 10 Hours 2½ Pieces
Labor Cost of a Days' Run of 10 Hours 3.75
Labor Cost of 1 Piece 1.31
Labor Cost of 50 Pieces 65.50
2ND OPERATION.
Chuck in Soft Jaws 5 Mins.
Rough Bore Front End 5 Mins.
Finish Turn Taper and Face End 30 Mins.
40 Mins.
Cost of Operating Machine 0.25
Output per Day of 10 Hours 15 Pieces
Labor Cost of a Days' Run of 10 Hours 3.75
Labor Cost of 1 Piece 0.25
Labor Cost of 50 Pieces 12.50
3RD OPERATION.
Chuck (use Special Fixture) 5 Mins.
Finish Bore for Pads 15 Mins.
Cut Groove for Pads 35 Mins.
55 Mins.
Cost of Operating Machine 0.34
Total 5 Hours, 5 Mins. 1.90
Output per Day of 10 Hours 11 Pieces
Labor Cost of a Days' Run of 10 Hours 3.75
Labor Cost of 1 Piece 0.34
Labor Cost of 50 Pieces 17.00
Total Labor Cost of 1 Piece 1.90
Total Labor Cost of 50 Pieces 95.00
Total Labor Cost of 50 Pieces with 125% Overhead added 213.75
Time Lost on 50 Pieces Compared with Automatic and Lathe Operations = 154 Hours.
Machinery

Fig. 5. Improved and Former Methods of making a Spring Collet, illustrating the Advantage obtained by performing First Operation on 7¾-inch Cleveland Automatic Screw Machine

by the large regulating drum located at the right-hand end of the machine.

The oil pump on this machine is positive driven and has an air cushion pressure chamber, which provides for a steady flow of the cooling liquid. It has a capacity for pumping oil at the rate of 23 gallons per minute. Oil is pumped to the end-working tools, such as drills, counterbores, etc., through a tube passing through the turret and connecting at each of the turret holes. The over-all length of the machine shown in Fig. 1 is 16 feet 6 inches, the bed casting weighs 6300 pounds and the entire weight of the machine, everything included but not crated, is 15,000 pounds—over seven tons. The machine is fully provided with guards over the exposed working parts and has ample chip room and oil guards.

Example of Work done on 7 3/4 inch Cleveland Automatic

An example of work which illustrates to a remarkable extent the productive capabilities of the machine shown in Fig. 1 is a spring collet or chuck for a 4¼-inch Cleveland automatic screw machine. Two of these collet blanks appear on the tray of the machine in the illustration. This spring collet is made from a rough round bar of 7½-inch 40-point carbon open-hearth steel. It is approximately 11 inches long, and the largest diameter is 7⅜ inches. Fig. 4 gives a comprehensive idea of the amount of work necessary to produce this piece, where it can be seen that 105 pounds of chips has been removed. A solid bar of 7½-inch stock equal in length to the spring collet weighs 143 pounds, whereas the spring chuck, in the condition in which it is dropped from the machine, only weighs 38 pounds. It requires exactly 48 minutes to complete one piece, so that approximately 2¼ pounds of chips is removed per minute—a somewhat remarkable performance for an automatic screw machine.

Another illustration of the economical manufacturing possibilities of this machine is a comparison of the present and former methods of making this spring collet for the 4¼-inch Cleveland automatic screw machine. In Fig. 5 the present and former methods are laid out diagrammatically. Here it can be seen that the time required to complete one of these spring collets on a hand-operated turret lathe was 5 hours 5 minutes at a labor cost of $1.90. The time now required to finish one chuck complete, including the hand turret lathe operations, is 2 hours 3 minutes at a labor cost of 45 cents; this represents a saving in time on each piece produced of 3 hours 2 minutes and a saving in labor cost of $1.45. The time gained by using the improved method on 50 pieces is 154 hours, and the saving in cost on this number, overhead charges of 125 per cent being added in both cases, is $157.50.

The reason for performing the third operation on the hand turret lathe is that this operation was added after it was found that the entire machining on the nose of the collet and in the hole could not be accomplished with the collet held in the manner illustrated for performing the second operation. The chief objection was that it was found impossible to get the hole to run true with the tapered end, owing to the heavy cutting necessary in producing the holes for the pads. The tapered end and the rear bearing of this collet is ground before hardening, the work being held on an arbor. This method was found to be much quicker than filing and polishing. The collet is not ground after hardening.

STANDARD ROLLING MILLS

The Standard Machinery Co., 7 Beverly St., Providence, R. I., is now building the two styles of cold rolling mills illustrated in Figs. 1 to 4. Figs. 1 and 2 show front and rear views of the No. 6 mill with rolls 8 inches in diameter by 10 inches face width. The No. 7 mill, front and rear views of which are shown in Figs. 3 and 4, has rolls 11 inches in diameter by 10 inches face width. The face width of the rolls on both machines can be varied to suit the requirements of different cases. On the No. 6 mill the rolls can be anywhere from 6 to 14 inches face width, while the No. 7 mill can be made with rolls from 8 to 18 inches face width. The standard No. 7 mill has rolls 10 inches in diameter by 15 inches face.

The No. 6 mill is direct connected to a type HF Westinghouse motor equipped with a special controller and special resistance coils in the circuit which are located under the bed of the machine. The motor develops 20 horsepower and

runs at 1150 revolutions per minute; it is capable of a 50 per cent decrease in speed with a corresponding decrease in horsepower. This variation of speed and power is governed by setting the controller lever in different notches and allows the operator to start the mill with heavy stock and then vary the speed and power as required. Roller bearings are provided on the roll journals which are said to effect a saving in power consumption of from 35 to 60 per cent. Without the use of roller bearings a 30-horsepower motor would be required to drive this mill. The rolls are made of chrome alloy steel with hardened journals and hardened bodies, the face of the roll being lapped to a mirror finish.

The adjusting screws seen directly below the large spur gear in Figs. 1 and 2 have a dial which is graduated to provide for making adjustments to 0.001 inch. The screws are left-hand and the gear ratio is 5 to 1; ample pressure is

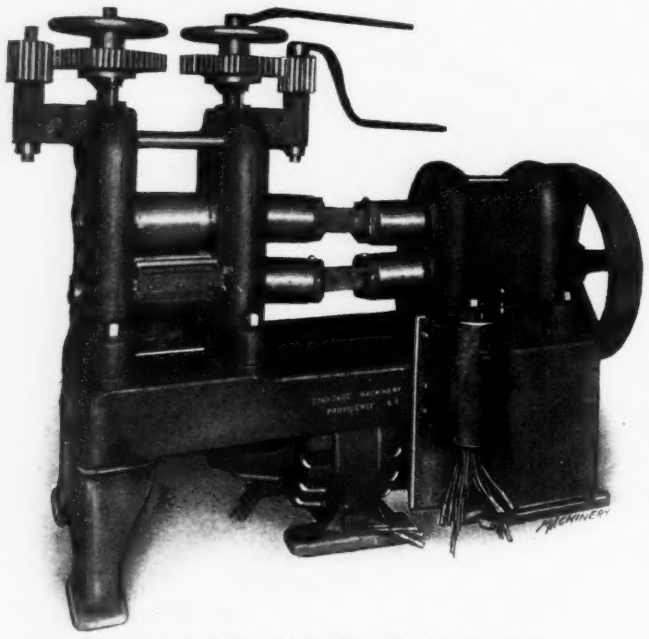


Fig. 1. Front View of Standard No. 6 Rolling Mill

supplied for rolling heavy and dense stock. The handwheels are provided for raising the screws rapidly when it is required to release the pressure from the work. The housings are of heavy construction. The machine is equipped with a running-out table at the rear, which is shown in Fig. 2, and a running-in swivel table with guides is provided at the front of the mill. Cut steel herringbone gears are provided in the gear housings and there are also two trains of spur gears exclusive of the motor train. The motor pinion is of rawhide and all other gearing is of steel with cut teeth.

revolutions per minute. The same provision is made for varying both the speed and horsepower of the motor that was previously described for the No. 6 mill. The roll journals run in ball bearings, but the way in which the rolls are adjusted is somewhat different from that described for the

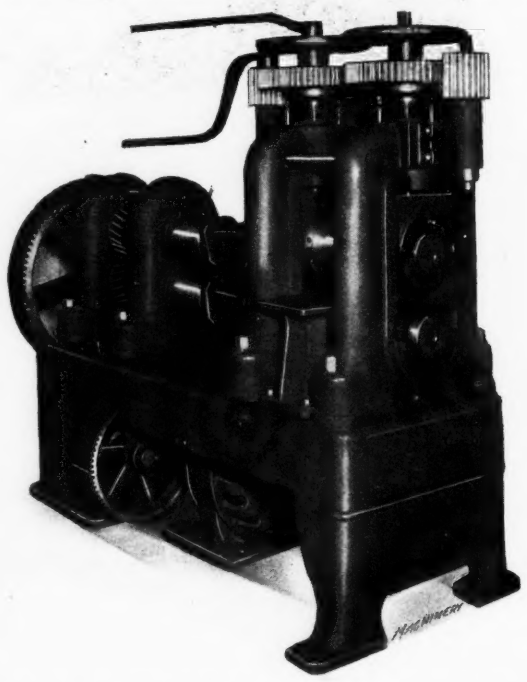


Fig. 2. Opposite Side of Standard Rolling Mill shown in Fig. 1

preceding machine. It will be seen that a center handwheel is provided which adjusts the two rolls simultaneously. The center pinion is so arranged that it can be slipped off, thereby allowing an independent adjustment from either of the screws or pinions. The screws are provided with dials for making adjustments to 0.001 inch. It will be seen that the motor is placed at one end instead of being underneath the bed of the machine. The transmission includes a pair of cut steel herringbone gears and three trains of spur gears. All of the gears, with the exception of the motor pinion, are of steel. The rolls are of hardened and ground chrome alloy steel, lapped to a mirror finish. The bed of the machine is cast in one piece. Below the inner gear housing there is a heavy rib which is bored at the same time that the outside bearings at the rear of the bed are bored; this affords a double bearing for each gear shaft. All of the bearings are bronze bushed.

BROWN & SHARPE DIRECT-READING MICROMETER

It takes quite a little experience to learn to use an ordinary micrometer and obtain the required measurement quickly,

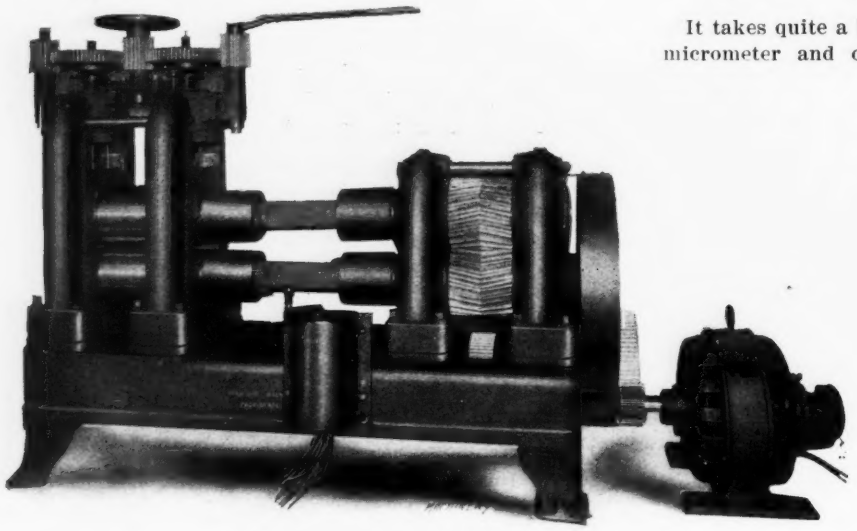


Fig. 3. Standard No. 7 Cold Rolling Mill

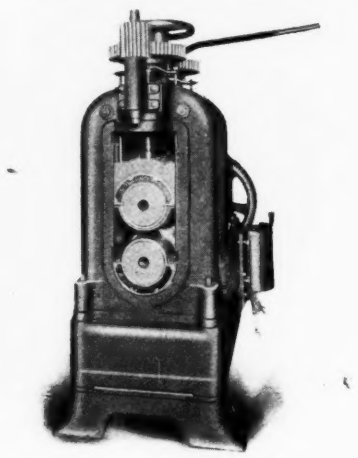


Fig. 4. Reverse Side of No. 7 Mill

The No. 7 mill shown in Figs. 3 and 4 is of similar construction to the No. 6 machine. This mill is driven by a 30-horsepower alternating-current motor which runs at 1150

and even the most experienced operator is likely to make a mistake in taking the reading. There are two classes of men to whom these difficulties are particularly objectionable, *i. e.*,

purchasing agents who desire to use a micrometer in measuring the gage of sheet metal, etc., and have not had sufficient experience to use the tool with any degree of rapidity; and inspectors who have to use a micrometer so often that the time involved in taking the readings is considerable. With the view of overcoming these difficulties, the Brown & Sharpe Mfg. Co., Providence, R. I., has brought out a direct reading

Fig. 1. Brown & Sharpe Direct Reading Micrometer

micrometer, shown in Fig. 1. This tool has a capacity up to 1 inch and is provided with the usual ratchet mechanism to prevent the possibility of damaging the screw. The micrometer, is used in the ordinary way, figures coming up in the three holes in the sleeve to give the reading direct. While arranged to give readings to 0.001 inch, the graduations on the collar enable the fourth decimal place to be accurately estimated.

The parts of the micrometer are shown in Fig. 2 and referring to this illustration the method of operation will be readily understood in connection with the following description. The part *A* is known as the first "counter" and is graduated with two series of figures as follows: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, which are equally spaced around the counter. These figures indicate thousandths of an inch. The part *B* is the second counter which is similarly graduated, this counter indicating hundredths of an inch. The barrel of the micrometer *C* is graduated with one set of figures, similar to the two sets on the counters *A* and *B*, these figures indicating tenths of an inch. The counter *A* is a press fit on the measuring screw *D*. This counter has a small pin *E* sliding in it engaging with the cam *F* which is held stationary in the sleeve *G* by means of two screws. The measuring screw is 50 pitch so that one revolution gives a lateral movement of 0.020 inch. Bearing in mind the graduation on the first counter *A*, it will be evident that one revolution of the screw causes all twenty figures on this counter to appear in succession through the hole in the sleeve.

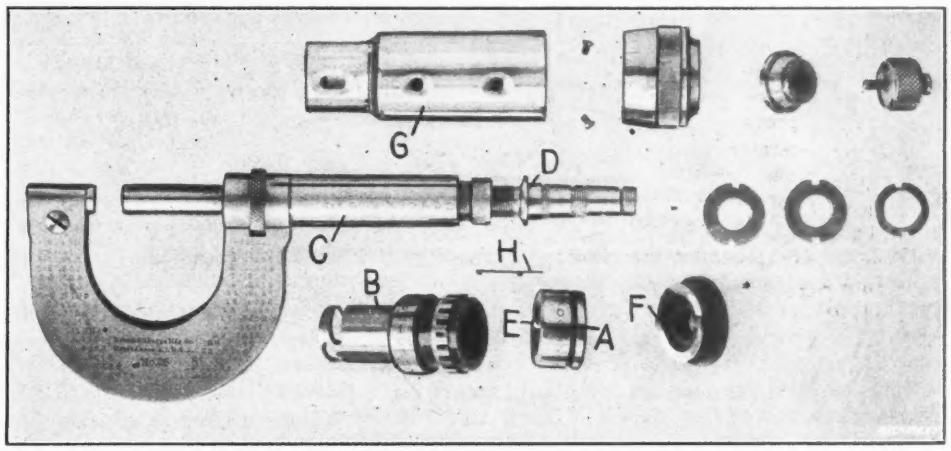


Fig. 2. Parts of the Brown & Sharpe Direct Reading Micrometer

When the counter *A* has made one-half revolution, the "carrier" pin *E* is pushed forward by the cam *F* so that it enters a hole in the end of the second counter *B*. At the same time the "locking" pin *H*, which normally fits into a slot in the counter *B* to prevent it from rotating, is drawn back through the action of a teat on this locking pin which runs in the cam groove in the first counter *A*. Under these conditions the counter *B* is moved through one-twentieth of a revolution to expose the "1" figure, indicating 0.010 inch. When this has been done, the teat on the locking pin *H* causes this pin to be pushed back into the next slot in the counter *B* and hold it stationary until the counter *A* has been rotated through another half revolution. When the locking pin is thrown back into engagement, the "carrier" pin *E* is moved back by the pressure exerted on its tapered end. This cycle is repeated each time the counter *A* is rotated through one-half revolution, which corresponds to a lateral movement of 0.010 inch of the measuring screw. For each half revolution of the counter *A*, the counter *B* is moved through one-twentieth revolution which also corresponds to 0.010 inch.

It has already been stated that the figures indicating tenths of an inch are graduated on the barrel of the micrometer. These figures are covered by the sleeve at the left-hand side of the counter *B*, the proper figure being exposed by a spiral groove cut through this sleeve which moves under the hole in the sleeve *G*. Each time the counter *B* has been rotated through one-half revolution so that ten figures have been brought up, a figure is brought up on the counter *C* indicating tenths of an inch. The principle upon which the operation of this micrometer is based will be clearly understood from the preceding description if it is borne in mind that the figure in each adjacent hole to the left has ten times the value of the adjacent figure to the right of it. The design of the mechanism has been cleverly worked out

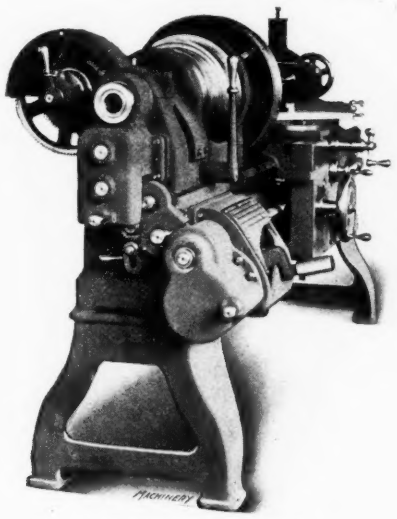


Fig. 1. End View of Cisco Lathe

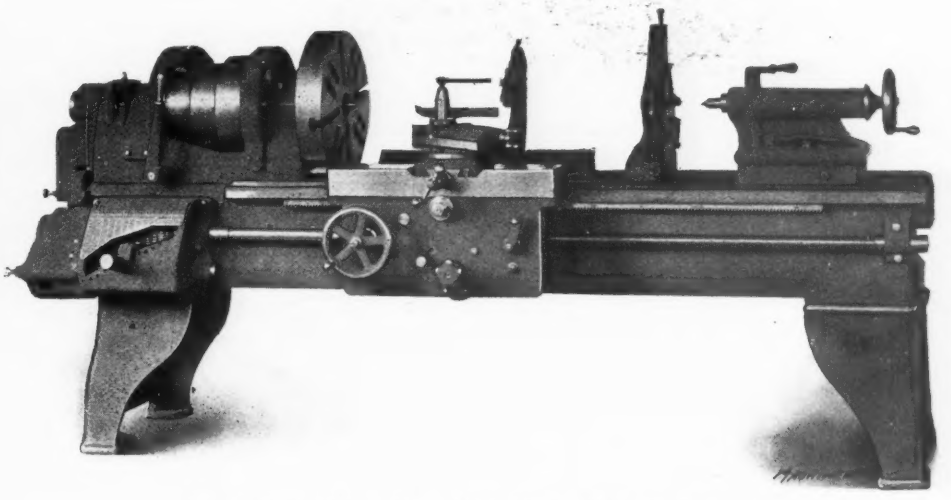


Fig. 2. Front View of Cisco 18-inch Lathe with Double Back-gears

CISCO EIGHTEEN-INCH LATHE

The Cincinnati Iron & Steel Co., Cincinnati, Ohio, has recently equipped its 18-inch lathe with a 3-step cone pulley and double back gears, a machine built in this way being shown in Figs. 1 and 2. The lathe is of very heavy construction and while nominally an 18-inch lathe it will actually swing up to 19½ inches. The hollow spindle will take

1⅞-inch stock and from 2 to 46 threads per inch may be cut. The ratios of the double back gears are 10 to 1 and 3.17 to 1, respectively. Particular attention is called to the sizes of the bearings which are 3½ by 5¾ inch at the front of the headstock and 3 by 4½ inches at the rear of the headstock. The lathe is of simple design and only two wrenches are needed for the entire machine.

All screws are hardened and all gears are of steel. All thread and feed changes are obtained instantly without requiring the removal of any gears or stopping the lathe. The thread and feed changes are obtained by means of two pull pins and the tumbler in the change gear box. The apron is worm-driven by means of a steel worm-wheel and bronze worm, the worm-wheel running in oil. A large graduated dial is provided for thread cutting, and the worm-wheel which operates this dial may be disengaged from the lead-screw when not in use by removing a single screw. The apron is of the double-plate type to provide back support for the studs. The design is such that the half-nut lever cannot be accidentally engaged and a non-interfering device makes it impossible to throw the feed and half-nut into engagement at the same time. The compound rest and cross-feed collars are graduated in the usual way. An efficient form of taper-turning attachment forms a part of the equipment. This lathe is built with beds ranging from 6 feet up. The 18-inch by 8-foot lathe weighs 3500 pounds and each extra foot of bed means an additional weight of 170 pounds.

Fig. 1. Three Types of Hisey-Wolf Portable Electric Drills for use interchangeably on Direct or Alternating Current

HISEY-WOLF ELECTRIC DRILLS

The Hisey-Wolf Machine Co., Cincinnati, Ohio, has recently added to its line three types of universal electric drills which can be operated interchangeably on alternating or direct current. These drills are made in five sizes which have capacities up to 3/16, 5/16, ⅜, ½, and ¾ inch, respectively, and range in weights from 6 to 35 pounds. The motors have ample torque and speed characteristics and a liberal factor of safety has been allowed in designing. Their ability to operate on either alternating or direct current makes these drills particularly convenient; they are connected from an ordinary lamp socket.

One of the noteworthy features of these tools is their simplified construction. The electrical and mechanical units are entirely separate so that injury to the mechanical parts does not affect the electrical parts, or *vice versa*. Anyone can take the drill apart in a short time and no other tool than a screwdriver is required. The drill can be assembled with equal ease and without danger of misplacing the electrical connections. By simply taking out four screws the back cap can be removed to expose all of the working parts on the commutator end. The drill can be run with the back cap removed so that the operating of the brushes, commutator, etc., may be inspected. The bearing is not carried in the back cap, but is supported by a separate bracket, as shown in Fig. 2. Besides the convenience of this arrangement for inspecting or making repairs, it avoids binding of the bearings and causing any unnecessary frictional load. All strains are carried on the frame and not on the working parts.

Fig. 2. Parts of a Hisey-Wolf Universal Drill

Taking out four screws will also enable the front cap containing the gears to be taken off to expose the armature, which can be readily removed without interfering with any of the wiring. The gears can be removed from the gear case with equal facility and all parts are interchangeable so that repair parts can be supplied. The leads to the motor are attached

to a terminal plate on the back bearing bracket. The cable is attached to corresponding terminals and protected by a fiber insulating cap. In case of damage to the cable, it can be readily replaced without danger of interfering with the motor connections. To do this, it is simply necessary to remove the insulating cap and attach a new cable to the terminals. The switch is of simple design and entirely enclosed. It is operated by a trigger in the permanent handle of the drill and the arrangement is such that the operator cannot get a shock.

All parts of the drill are made of aluminum where this material is suitable; other parts are made of steel. This construction insures the lightest weight that is consistent with satisfactory service. The armature shaft runs in ball bearings and a ball thrust bearing takes the load from the chuck spindle. All bearings are enclosed and run in grease. The gear-case is enclosed and all bearings on the chuck end of the drill are lubricated from the gear-case. The motor is air-cooled by a fan on the armature shaft.

TERRELL'S STEEL SHELVING WITH LOCKED DOORS

Steel doors that may be readily attached to any of the standard shelving units made by Terrell's Equipment Co., North Grand Rapids, Mich., provide tightly closed compartments for the safe storage of material that is too delicate or valuable to be kept on open shelves. These doors may be supplied with new shelving or added to existing installations, and like all of the other equipment built by this company, they are made on the unit plan which provides for expansion or rearrangement. They are hinged to a channel frame of special design, which is fastened to the unit in such a way that no bolts are exposed, making it impossible for the doors to be opened or removed without unlocking. The doors are furnished in four heights and widths, so that open and closed compartments may be combined in a single installation, as desired.

Steel racks equipped with these locked doors afford protection against the theft of material or loss from fire. The channel frames that carry the doors are provided with lugs by means of which they are bolted to the uprights. The attachment of the doors does not interfere with the adjustment of the shelving in any way. As previously stated, the doors are built on the unit system, each unit comprising a complete frame and pair of doors. The doors are fitted with a three-way locking device that secures them at three points, *i. e.*, a center latch and a locking rod at the top and bottom. The doors can be fitted with master-key locks, with padlock attachments, or without locks. The frames can be stacked, so that where the shelving is higher than the highest standard door, smaller doors may be used in double or triple tiers.

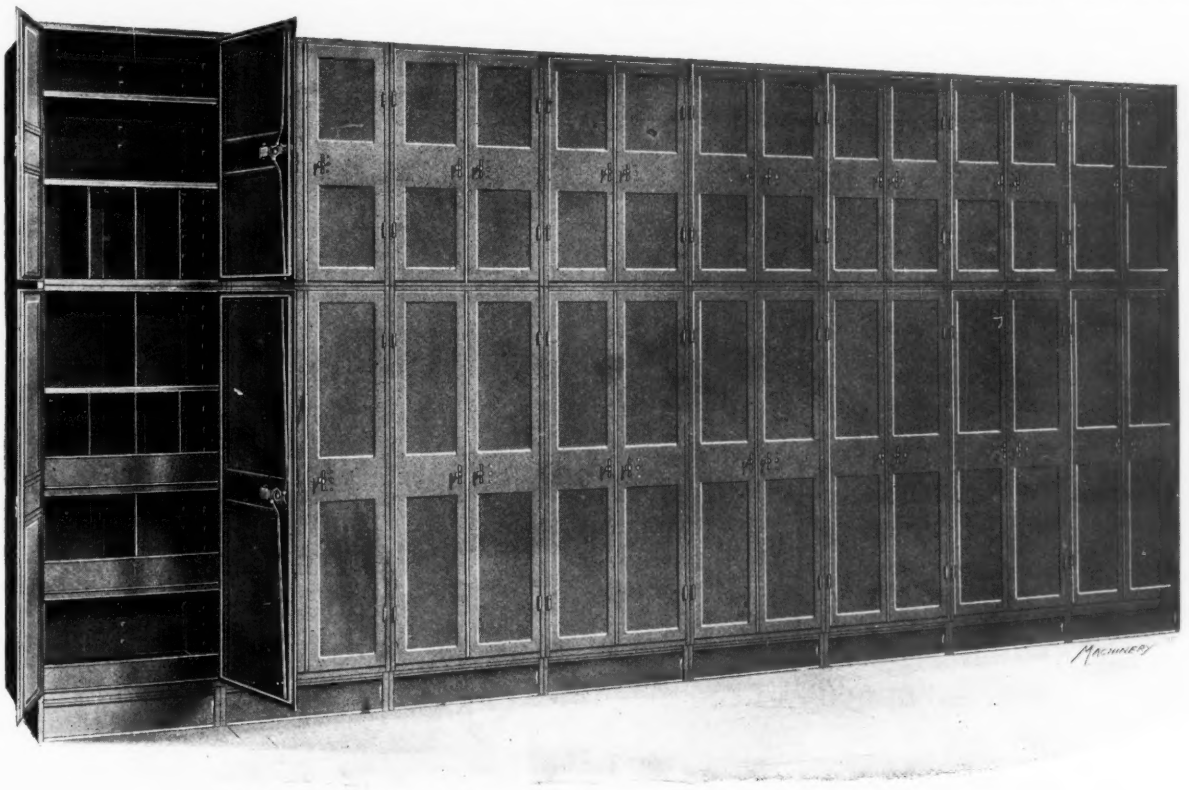


Fig. 1. Installation of Terrell's Steel Shelving provided with Locked Doors

NEW MACHINERY AND TOOLS NOTES

Motor-driven Grinder: Forbes & Myers Co., Worcester, Mass. This company is now building its motor-driven grinding machine mounted on a column which makes it entirely self-contained.

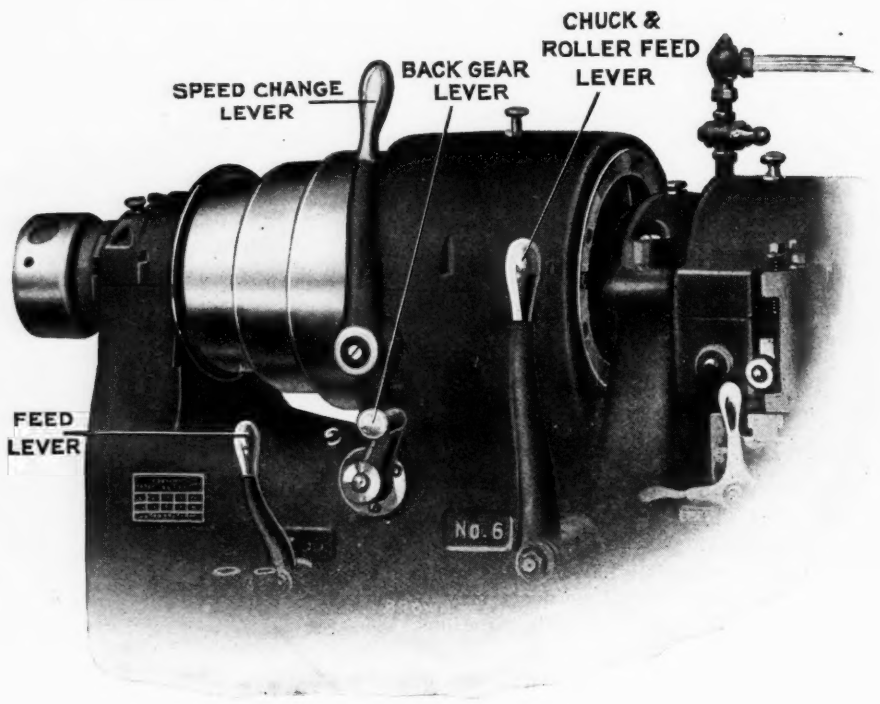
Fig. 2. Rear View of Door showing Method of Attachment

Polishing Machines: W. V. Robinson Co., Owosso, Mich. Two automatic polishing machines; one of these machines is intended for pipe polishing and the other is used for polishing stove tops, sad irons and similar classes of work.

Safety Lathe Dog: E. J. Michaud, Willimantic, Conn. A straight tail lathe dog which has no protruding set-screw that may endanger the operator. The screw boss or crown on the dog is longer than the screw, thus effectually covering it.

Nut Tapping Machine: Erie Machine Shops, Erie, Pa. An automatic nut tapping machine equipped with a stationary tap and belt conveyor for feeding work to the spindle. The machine is intended for tapping either square or hexagon nuts.

Electric Lamp Bracket: W. H. Hill, Cambridge Springs, Pa. An adjustable lamp bracket provided with universal adjustment that is particularly adapted for use in machine shops for obtaining the most advantageous light in the operation of machine tools.



Three Lever Control

Note the arrangement of the levers in cut above. One lever opens the chuck, feeds the stock and locks the chuck again. Starting, stopping and changing speeds is accomplished by a second lever, while a slight movement of the third lever changes the feed for the turret slide.

This Means Fast Production

The levers are all near the operator's left hand while he manipulates the turret or cross slide with his right. Thus he works with both hands and can make every move count. The roller feed handles round, square or hexagonal stock and feeds any length without adjustment. It is quickly set for any size of bar. The variable turret slide feed can be changed while machine is running and will pull any cut within capacity of the machine.

BROWN & SHARPE MFG.

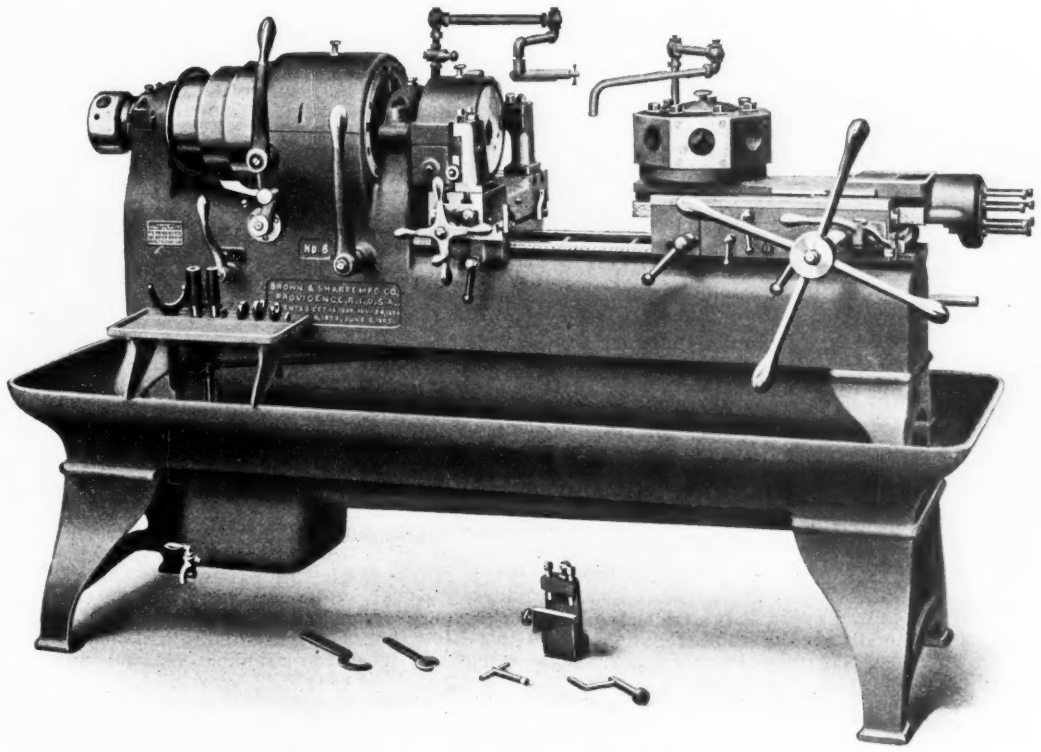
No Extra Collets

By means of a wrench furnished with the machine the jaws of the Automatic Chuck can be set the same as a Universal, to grip any size of stock within its capacity. The same chuck takes either round, square or hexagonal stock with equal facility.

This Saves Time and Equipment

An expensive stock of heavy collets is avoided. There is no time spent hunting up and adjusting collets when changing jobs. No long waits are necessary for collets to hold odd sizes of bars. The machine is always ready.

The adjustment of the chuck is easily and quickly made. The grip is unusually strong because of the powerful leverage. It is always the same along the bar, for the chuck compensates for variations in the stock.



No. 6 Wire Feed Screw Machine
Capacity: Takes stock ½" to 2" in diameter. Turns 10" long.

CO., Providence, R. I., U. S. A.

READ PAGE 67

Vise: E. A. Lueck Co., Milwaukee, Wis. A drill press vise equipped with a coarse pitch screw to provide for rapid operation. V-slots are provided for holding round work. The maximum opening between the jaws is 4⅞ inches and the vise weighs 31 pounds.

Factory Truck: George P. Clark Co., Windsor Locks, Conn. A shop truck provided with a lifting device operated by the handle of the truck. This lifting device is controlled by an arrangement of cams and gears which reduces the effort required in lifting the load.

Two-spindle Drilling Head: Nelson-Blanck Mfg. Co., Detroit, Mich. The spindles of this head are adjustable to adapt it for handling a large variety of work requiring two holes to be drilled. The maximum distance between centers is 8⅜ inches and the minimum 1⅝ inch.

Alligator Shear: Hilles & Jones Co., Wilmington, Del. A motor-driven shear mounted upon a truck to adapt it for portable service. The knives are 14 inches long and the machine operates at 50 strokes per minute. The capacity is up to 1½ inch square soft steel bars cut cold.

Straightening Rolls: Hilles & Jones Co., Wilmington, Del. A set of heavy plate straightening rolls which are said to be among the largest rolls of this type which have been built in this country. The machine is operated by a 100 horsepower Westinghouse variable speed motor and weighs 120,000 pounds.

Crank-driven Planer: Newton Machine Tool Works, Inc., Philadelphia, Pa. The notable feature of this machine is the incorporation of a geared speed box which provides a useful range in cutting speeds with a single pulley drive. The machine may also be equipped with electric motor drive when so desired.

Lathe: Von Wyck Machine Tool Co., Cincinnati, Ohio. A 16-inch quick change gear lathe equipped with double back gears. The machine has a chasing dial which permits thread cutting to be handled without stopping the lathe or reversing the lead-screw. The double back gear ratios are 12 to 1 and 3½ to 1.

Keyseating Machine: Newton Machine Tool Works, Inc., Philadelphia, Pa. A keyseat milling machine built for the C. Morgan Smith Co., York, Pa. This machine is intended for milling the keyseats in locomotive engine axles, the full depth, width and length of the keyseat being finished in a single operation.

Milling Machine: John Steptoe Shaper Co., Cincinnati, Ohio. This company has improved its hand milling machine by adding a quick return mechanism for the table feed, a new lever latch, and a table of increased length. These improvements have been added to the regular screw elevating knee type of milling machine.

Multiple Punch: Cleveland Punch & Shear Works Co., Cleveland, Ohio. A large multiple punching machine for use in steel car fabricating work. The machine has a capacity for punching sixty 3/16-inch holes in a 1 1/2-inch steel plate. The punches are arranged in two rows of thirty each and their positions are adjustable.

Milling Saw: Henry Disston & Sons, Inc., Philadelphia, Pa. A 36-inch high-speed segmental milling saw composed of six segments. The spaces between these segments take up temporary strains which might damage a solid saw. Making the saw in segments is also said to afford a possibility of getting better results in hardening.

Lathe: National Lathe Co., Batavia, Ohio. A 17-inch lathe. The carriage of this machine is gibbed front and back and the apron is equipped with an interlocking mechanism. The head is provided with a reverse mechanism which adapts the machine for cutting right- and left-hand threads. The change gear device is of a special patented construction.

Hydraulic Steam Pump: Hydraulic Press Mfg. Co., Mt. Gilead, Ohio. A line of steam-driven hydraulic pumps equipped with a new form of speed and pressure regulator. Based on the steam end dimensions, this line of pumps comprises twelve sizes, and on the water end dimensions, seventy-one sizes. The pump is of the single cylinder, double-acting pattern.

Multiple Spindle Drilling Machine: Moline Tool Co., Moline, Ill. A multiple spindle machine built along the established lines which are followed in the construction of the machines of this company's manufacture. This machine is intended for hollow milling work; it is equipped with drill chucks for holding the work and hollow mills made by the Modern Tool Co.

Boring Tools: Davis Boring Tool Co., St. Louis, Mo. A set of boring tools which has some unusual features, among which the following may be mentioned. The cutters are unusually heavy and the bodies of the tools are also made heavier to afford the necessary support for boring operations on a particularly tough grade of steel. The bodies are made flat on two sides to afford the necessary chip clearance.

Milling Machine: American Milling Machine Co., Batavia, Ohio. A No. 1½ plain milling machine in which particular attention has been paid to the provision of safeguards over all dangerous parts. Another noteworthy feature of the design is the simplicity of the operating mechanism. Twelve geared feed changes are provided which are in geometrical progression and cover a range from 0.005 to 0.030 inch per revolution of the spindle.

Belt Tension Scale: Tabor Mfg. Co., 18th & Hamilton Sts., Philadelphia, Pa. A gage particularly adapted for use in textile mills where there are a large number of small belts of the same approximate thickness and length. This device is placed on the belt and a handle is turned which causes tension to be applied by means of a spring, the tension being indicated on a scale. In this way accurate information may be obtained as to whether the belt requires tightening.

Shop Goggles: T. A. Willson & Co., Inc., Reading, Pa. Improved shop goggles for use in operating grinding machines and similar classes of work. The lenses are pivoted to the bridge so that they may be adjusted to fit closely around the nose and eyes of different wearers. A special flange construction is said to make it impossible for the glass to be forced inward in event of the lenses being broken. The usual form of gauze guards are provided to prevent chips from flying into the workman's eye from the side.

Multiple Drill Head: Covington Multiple Drill Co., E. 5th & Scott Sts., Covington, Ky. A drill head adapted for clamping directly to the spindle sleeve of an ordinary drilling machine. The main driving gear of the head is driven by a double-end key placed in the tang slot or drift hole of the spindle. The head is made to take drills with No. 2 Morse taper shanks in sizes up to 29/32 inch. The head has a maximum spread of 11 1/16 inches and a minimum of 4 5/16 inches. The body of the head has a circular dovetail around it. The brackets holding the spindles are gibbed to this dovetail and may be adjusted to different positions.

* * *

NEW YORK STATE COMPENSATION ACT FOR WORKMEN

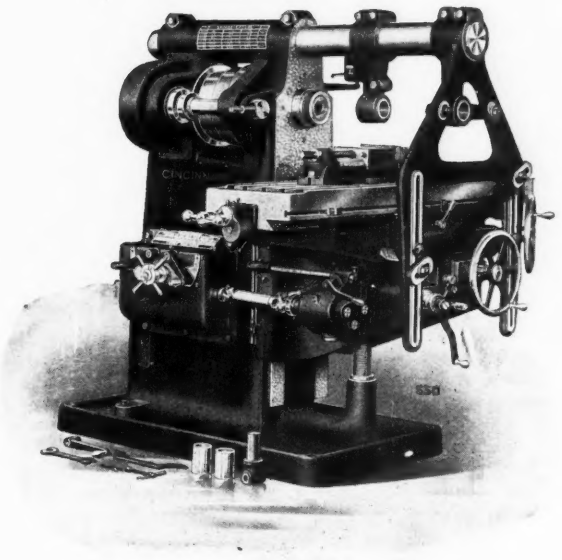
The New York State Legislature passed a workmen's compensation act December 12 which is said to be the most carefully drawn compensation law yet passed by any American state. Following are the principal features of the law:

1. It requires employers in forty-one enumerated groups of the hazardous industries to insure the payment of compensation to their injured employes and makes such compensation the exclusive remedy.
2. It gives employers the choice of four methods of insurance: (*a*) in the state fund created by the act; (*b*) in employers' mutual insurance associations; (*c*) in casualty companies; or (*d*) to carry their own insurance on satisfying the state compensation commission of their financial ability to pay all lawful claims.
3. It creates a compensation commission of five members to administer the state fund and to investigate, settle and pay the claims of all injured employes, acting as the agent of the state fund or of the other insurance carriers.
4. It gives this commission adequate powers to organize the force of deputies, actuaries, examiners, etc., necessary to the efficient performance of its duties.
5. It prescribes a carefully balanced scale of compensation, based on two-thirds of the wages of the injured employe and the limit of $15 a week as a standard, and includes all of the important provisions suggested by European and other experience. The payment of compensation begins on the fifteenth day after the injury.
6. It requires employers to provide medical attendance, medicines, surgical appliances, hospital care, etc., "to a reasonable amount" from the time of the accident until sixty days thereafter, but with careful limitations designed to protect employers from unreasonable charges and to prevent malingering.
7. It authorizes employers in any one of the enumerated groups to organize mutual associations for the prevention of accidents and to draft rules, which when approved by the industrial board, shall have binding force.

* * *

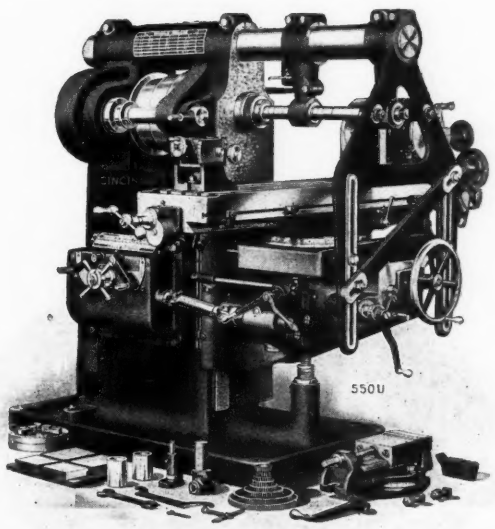
The Red D steamship *Zulia* sustained a peculiar accident while loading a forged steel shaft weighing several tons at her pier in Brooklyn December 8. The shaft, which was about eighteen feet long, was encased in a wooden shipping box, and as it was being hoisted aboard by a sling around the middle, the shaft overbalanced and one end swung downward. The heavy shaft broke through the box and plunged into the hold, breaking a hole through the bottom of the vessel. The hold was flooded with water, causing a loss of $25,000 to the cargo.

Much of the Milling in most Shops is not Heavy Cutting



The No. 4 Plain High Power Miller with Cone Drive

Front or operator's side showing arrangement of all operating levers



The No. 4 Universal Power Miller with Cone Drive

On this work the very powerful single pulley millers do not increase production.

An up-to-date, properly designed, cone-driven machine like our No. 4 Horizontal often proves the better investment.

It is our High Power Miller with cone-driven spindle.

We have simply replaced the Single pulley, Geared Spindle Drive box with a Double Back Geared Cone of large diameter.

It has ample power for all that work requiring a large machine, but not excessively heavy cutting.

It can be depended upon for long, hard, continuous service, because of its massive "High Power" construction.

Its maintenance cost is low because of its simplicity.

AND IT IS HANDY.

The Feed Changers and Back Gear Lever are where the operator stands to shift the belt.

The Table always feeds in the direction in which the Engaging Lever is set.

This same lever also reverses the feed.

All Controlling Levers are at the front of the knee and saddle. So is the Quick Return.

Everything that has to do with its operation is within easy reach.

And there is an additional lever at the side of the knee controlling the feeds from behind the table, for end-milling or boring or similar work which can't be successfully done when the operator stands in front, as he must do on all other Millers.

Let us help on your milling problems. We make the largest variety of machines and therefore can recommend the ones best suited for your work.

THE CINCINNATI MILLING MACHINE CO.

CINCINNATI, OHIO, U. S. A.

EUROPEAN AGENTS: Alfred H. Schutte, Cologne, Berlin, Brussels, Milan, Paris, Barcelona, St. Petersburg. Donauwerk Ernst Krause & Co., Vienna, Budapest and Prague. Sam Lagerlofs, Stockholm, Sweden. Chas. Churchill & Co., London, Birmingham, Manchester, Newcastle-on-Tyne and Glasgow.

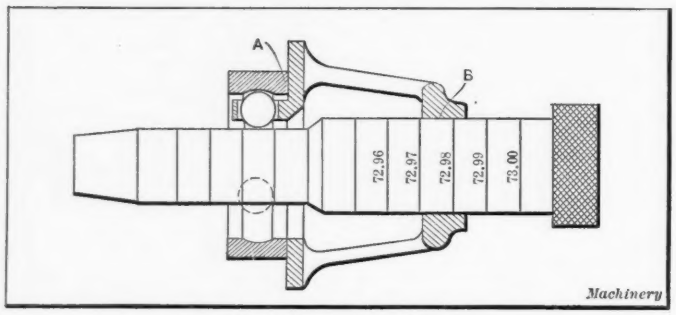
CANADA AGENT: H. W. Petrie, Limited, Toronto, Montreal and Vancouver. **AUSTRALIAN AGENTS:** McPherson's Pty., Ltd., Melbourne.

JAPAN AGENTS: Andrews & George, Yokohama. **CUBA AGENTS:** Krajewski-Pesant Co., Havana.

ARGENTINE AGENTS: Robert Pusterla & Co., Buenos Aires.

GAGE FOR BALL BEARING RACES

The accompanying illustration shows a gage for measuring ball bearings, which was recently patented in Germany. This gage has a new shape of mandrel which gives reliable and accurate readings without the addition of delicate parts. Instead of a conical tapering shape, the mandrel has a series of steps or cylindrical surfaces of varying size. These steps differ very little in diameter, the difference depending upon the degree of accuracy required. The contact bodies between the



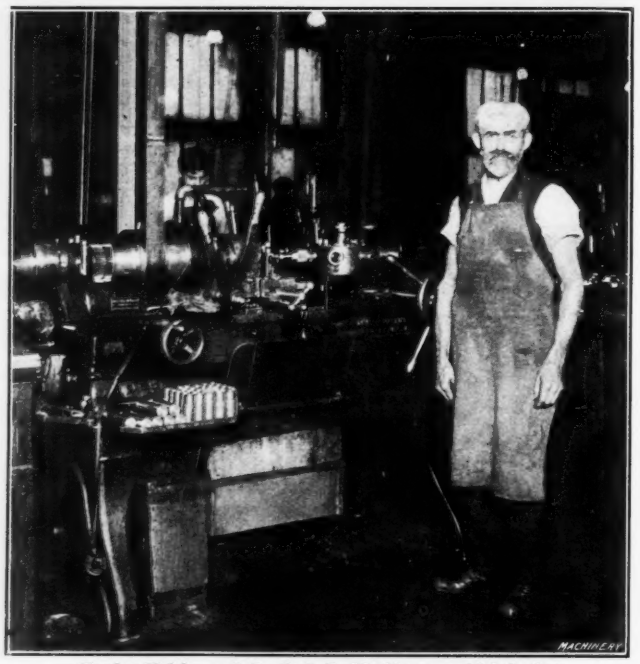
Gage for testing Ball Bearing Races

gage and the race to be measured should, preferably, be of the same steel as the balls to be used in the bearing. Three or more of these balls are inserted in the race, and the face of the supporting frame of the gage is placed against the finished face *A* of the ring. The cylindrical portion or shank of the mandrel passes through guide ring *B* and the step-shaped measuring end is pushed through between the balls. The face of the guide *B* forms an edge from which the reading is taken, as indicated by the graduations.

* * *

WESTINGHOUSE MACHINIST TWENTY-TWO YEARS ON ONE MACHINE

In the East Pittsburg Works of the Westinghouse Electric & Mfg. Co. is a man who has worked constantly at one machine for over twenty-two years, and furthermore holds the remarkable record of having been late to work in the morning only once during this period of years. The man possessing this record is Charles Heisler, who was born in Gutenberg, Germany, in 1864 and came to this country in 1881. After working in several different machine shops he secured employment in April, 1891, at the Westinghouse Electric Co.'s shops then located on Garrison Alley, Pittsburg, Pa. The young machinist was assigned to work on a two-inch Jones & Lamson turret lathe and has operated it continuously ever since.



Charles Heisler and the J. & L. Machine on which he has worked Twenty-two Years

This constancy in his daily work is entirely of his own choosing, as Mr. Heisler has on several occasions been offered work on other machines and of more modern design necessitating less labor to operate, but he has consistently refused, preferring, like the shoemaker, to "stick to his last." But long service is not a rare occurrence at the East Pittsburg works; in the same division with Mr. Heisler, which employs something like seventy men, there are eight employes whose time of service with the company ranges from seven to twenty-two years. In fact, most of the men now occupying the highest executive positions with the company have attained them through promotions from their respective departments. In the case of Mr. Heisler, the conditions surrounding his work were not particularly conducive to his advancement along the lines that some of the others followed, but his devotion to his work and continuity of purpose show a record seldom equaled and rarely exceeded in industrial circles.

* * *

PERSONALS

I. H. Page has retired from the position of treasurer of the Stevens-Duryea Co., Chicopee Falls, Mass.

W. H. Shafer, factory manager of the Rochester Boring Machine Co., Rochester, N. Y., has resigned his position. Mr. Shafer has as yet made no plans for the future.

J. M. Schaeffer of Waterbury, Conn., who has been the European representative of the Waterbury Farrel Foundry & Machine Co. for the past year and a half, has returned to Waterbury from abroad.

W. S. Parrish, who for the past three and a half years has been acting manager of the Kirkham Motor Mfg. Co., Bath, N. Y., has resigned his connection with the company. Mr. Parrish has made no definite plans for the future.

E. W. Cleveland, formerly chief draftsman for the Fox Machine Co., Grand Rapids, Mich., and designer of the Fox line of adjustable multiple spindle drills, is now with the National Automatic Tool Co., Richmond, Ind., in a similar capacity.

Dr. Ing. Herbert Kienzle, a German electrical engineer, who is interested in the design and construction of automatic screw machines and has written a book on the subject, is at present in this country with the intention of visiting the various concerns making automatic machinery. Dr. Kienzle expects to stay a month in America.

David L. Ballard on January 1 severed a connection of seventeen years standing with the Jones & Lamson Machine Co. in the selling field. His territory ranged from the Middle States to the Pacific Coast, but he is known and loved as "Uncle Dave" the country over among machine tool sellers and machine tool buyers. His friends in Chicago and vicinity gave him a farewell banquet on December 5 at the Auditorium Hotel. Here the older men to whom he has been a brother, and the younger men to whom he has been a father, met to express their regard for him, and to do him the honor at his retirement that the character of his active life has so richly merited.

* * *

OBITUARIES

William Deering, founder of the Deering Harvester Co., which was absorbed into the International Harvester Co., died at his winter home in Cocoanut Grove, Florida, December 9, aged eighty-seven years. He began the manufacture of harvesting machines at Plano, Ill., in 1873. His estate is valued at $12,000,000 to $13,000,000.

DANIEL M. BARTON

Daniel M. Barton, general purchasing agent of the General Electric Co., died at his home in Schenectady, N. Y., December 8 after an illness of only five days, aged seventy years. Mr. Barton was one of the oldest employes of the General Electric Co. He was born in Moriah, N. Y., in 1843; he lived there but a few years, his parents moving to Ware, Mass., when he was still a child. At the age of nineteen he enlisted in the army, with his brothers, in the Tenth Regiment Massachusetts Volunteers and fought at Fredericksburg and Gettysburg. In 1883 the Thomson-Houston Electric Co. was formed by citizens of Lynn, Mass., and a brother, Silas A. Barton, was an active organizer of the new company. Three years later Daniel M. Barton became production manager of the company. In 1893 Mr. Barton was made assistant purchasing agent of the newly organized General Electric Co., and a few years after the main office of the company was established at Schenectady he became general purchasing agent, which position he ably filled to the time of his death. He was well and favorably known throughout the business world, and his many friends and business associates will read of his death with regret. Mr. Barton is survived by his wife, a daughter, Mrs. Robert E. Nivison, and three grandchildren. He also leaves a brother, Silas A. Barton of Waltham, Mass., and a sister, Vila Barton of Northampton, Mass.

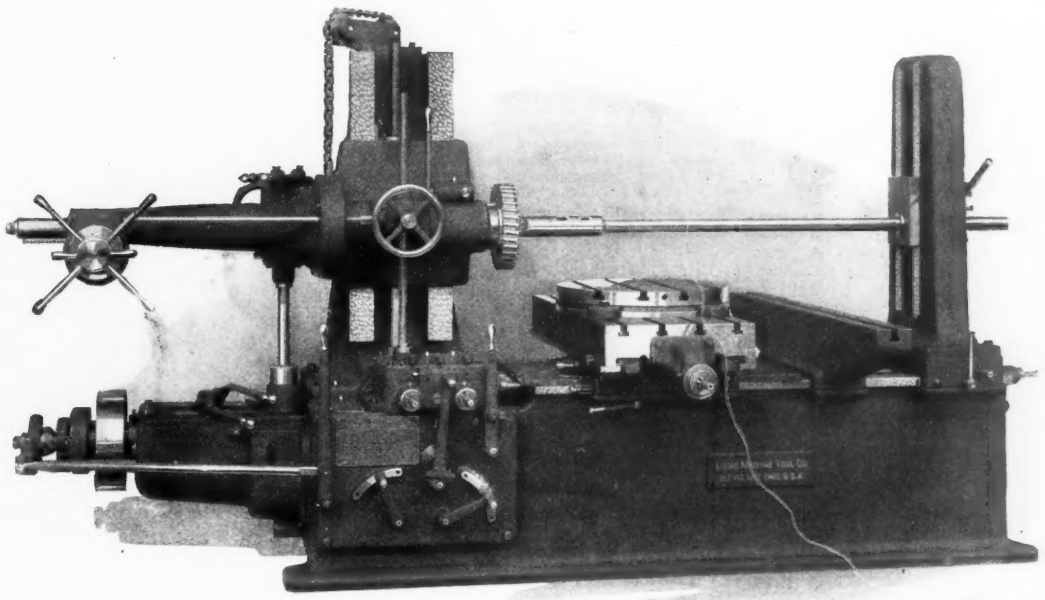
You Don't Very Often See a

LUCAS

"PRECISION"

Boring, Drilling and Milling Machine

in a second-hand list, do you? And when you do, it doesn't STAY in the list very long, does it—in spite of the fact that we've sold nearly 800 new ones too. When a second-hand "PRECISION" IS sold, it always



BRINGS A GOOD PRICE. In other words, a "PRECISION" user seldom wants to sell it, but if he does, HE CAN SELL IT

P. D. Q.

or in the words of one of our customers, "The 'PRECISION' is ALWAYS AN ASSET."

Lucas Machine Tool Co., NOW AND ALWAYS OF Cleveland, O., U.S.A.

AGENTS: C. W. Burton, Griffiths & Co., London. Alfred H. Schutte, Cologne, Berlin, Brussels, Paris, Milan, St. Petersburg, Barcelona, Bilbao. Donauwerk Ernst Krause & Co., Vienna, Budapest, Prague. Overall, McCray, Ltd., Sydney, Australia. Andrews & George, Yokohama, Japan. Williams & Wilson, Montreal, Canada. H. W. Petrie, Ltd., Toronto, Ont.

COMING EVENTS

January 3-10.—Fourteenth Annual Automobile Show, Grand Central Palace, New York City, under the auspices of the Automobile Chamber of Commerce, S. A. Miles, manager.

April 4-11.—First National Efficiency Exposition and Conference, Grand Central Palace, New York City. Walter H. Tallis, director, Efficiency Society, Inc., 41 Park Row, New York City.

May 1-October 31—Anglo-American Exposition, London, England, to celebrate the centenary of peace between the United States and Great Britain. American executive offices: Woolworth Bldg., New York City. Charles J. Kiralfy and Albert E. Kiralfy, commissioners general.

September 20-25 (1915).—International Engineering Congress, San Francisco, Cal., in connection with the Panama-Pacific International Exposition. W. F. Durand, chairman, Foxcroft Bldg., San Francisco, Cal.

NEW BOOKS AND PAMPHLETS

The Metric Carat. 12 pages, 7 by 10 inches. Published by the Department of Commerce, Washington, D. C., as Circular No. 43 of the Bureau of Standards.

The Testing of Materials. 89 pages, 7 by 10 inches. Published by the Department of Commerce, Washington, D. C., as Circular No. 45 of the Bureau of Standards.

House Heating Fuel Tests. By W. H. Meeker and H. W. Wagner. 85 pages, 6 by 9 inches. 16 illustrations and diagrams. Published by the Engineering Experiment Station of the Iowa State College, Ames, Iowa, as Bulletin 33.

Coal-Mine Accidents in the United States and Foreign Countries. Compiled by Frederick W. Horton. 102 pages, 6 by 9 inches. Published by the Department of the Interior, Bureau of Mines, Washington, D. C., as Bulletin 69.

Preliminary Report on Uranium, Radium and Vanadium. By Richard B. Moore and Karl L. Kithil. 101 pages, 6 by 9 inches. Published by Bureau of Mines, Department of the Interior, Washington, D. C., as Bulletin 70, Mineral Technology 2.

Fees for Electric, Magnetic and Photometric Testing. 23 pages, 7 by 10 inches. Published by the Department of Commerce, Washington, D. C., as Circular No. 6 of the Bureau of Standards.

This pamphlet quotes the charges made for testing electric, magnetic and photometric apparatus by the Bureau of Standards at Washington.

Mechanical Refrigeration. By H. J. Macintire. 346 pages, 6 by 9 inches. 121 illustrations. Published by John Wiley & Sons, Inc., New York City. Price $4 net.

This treatise for technical students and engineers describes the progress of mechanical refrigeration during the last decade. Not only has the construction been improved, but experimental work has been done to determine the properties of the refrigerants, etc. The contents by chapter heads are: Types of Refrigerating Machines and Their Construction; Auxiliaries; The Theory of Mechanical Refrigeration; Refrigerating Mediums—Their Choice and Properties; Testing the Refrigerating Machine; Insulation; Applications—Cold Storage; Applications—Cooling of Air; Applications—Cooling of Liquids and Solids; Economy of Refrigeration, etc. The chapter on refrigerants has been made as complete as possible, comprising experimental tests on anhydrous as well as aqua ammonia installations. Four chapters are devoted to applications. The work is one that should meet with appreciation by students and engineers and others identified with refrigerating plants.

Electrical Blue Book 1913-14. 227 pages, 9 by 12 inches. Published by the Electrical Review Publishing Co., Chicago, Ill. Price $2.

The sixth edition of the "Electrical Blue Book" represents an improvement on previous editions, the aim of the publisher being to provide in the most compact form possible complete information regarding the rules of the National Electrical Code. The list of approved fittings as published by the Board of Fire Underwriters and illustrations of the products of the leading manufacturers of electrical material which have passed tests recommended by the National Fire Protection Association as conducted by the Underwriters' Laboratories are features. The National Electrical code is illustrated and explained. This code has grown out of the efforts on the part of the fire insurance organizations to prevent installation of defective electrical wiring. These rules were originally recommendations but they have been so clearly formulated and so promptly modified to meet changing conditions that they are now regarded as little less than mandatory laws, specifying the rules of safety for electric wiring apparatus. The electrician and electrical contractor will find the book not only a guide for the installation of apparatus but a directory of the electrical supply manufacturers furnishing approved apparatus.

Motion Study. By Frank B. Gilbreth. 116 pages, 5¼ by 7½ inches. Illustrated. Published by D. Van Nostrand Co., New York City. Price, $2.

This work describes the author's method for increasing the efficiency of workmen. It emphasizes the necessity of motion study in scientific management, the great field for such study and the variables involved. The variables of the worker include his anatomy, brawn, creed, earning power, experience, habits, health, mode of living, size, skill, temperament and training. Other factors which affect the worker's efficiency are his state of mind or contentment, his resistance to fatigue and his food or nutrition. Another set of variables designated as surroundings are appliances, clothes, color, entertainment, heating, lighting, quality of material, rewards and penalties, size of unit used, special fatigue-eliminating devices, surroundings, tools, union rules and weight of unit moved. A third set of variables are those of motion, being acceleration, automaticity, combination with other motions, cost, direction, effectiveness, foot-pounds of work accomplished, inertia and momentum overcome, length, necessity, path, play for position and speed. The author has taken bricklaying as a type of skilled labor to illustrate these principles of motion study. The book is one of much suggestive value to those interested in any phase of so-called efficiency engineering.

Questions and Answers on Automobile Design, Construction and Repair. By Victor W. Page. 622 pages, 5 by 7½ inches. 329 illustrations. Published by Norman W. Henley & Sons, New York City. Price $1.50.

This book embodies the general editorial experience of the writer while technical editor of an automobile journal. The endeavor was made to arrange the contents in logical, systematic order and to describe principles of construction with special reference to the requirements of the non-technical reader. The contents comprise the following chapters: Modern Gasoline Automobile and its Principal Parts; Action of Two- and Four-Stroke Cycle Motors; Parts of Gasoline Motors and their Functions; Fuels for Automobile Motors; Theory of Carburetion and its Application; Types of Carbureters and Their Action; How Gas is Exploded in Cylinder to Produce Power; Parts of Ignition Systems and their Purposes; Current Producers, Batteries, Dynamos and Magnetos; Low Tension Ignition Systems; High Tension Ignition Systems; Methods of Lubricating the Automobile Power Plant; Cooling the Gasoline Engine by Air; Typical Water Cooling Systems; Use of Clutch and Various Types Described; The Friction Transmission; Individual Clutch Change Speed Gear; Action of Sliding Gear Transmissions; Methods of Drive to Rear Wheels; Differential Gear Construction and Operation; Rear Axle Types; Automobile Frames and Springs; Steering Gear and Front Axle; Wheels, Rims and Tires; Automobile Bearings and their Care; How to Start and Control Automobile Power Plants; Methods of Speed Changing Outlined; Utility of Brakes and their Use; General Driving Instructions; Oiling the Automobile Chassis; Road Troubles and their Symptoms; Repairing Power Plant Group; Troubles with Power Transmission Parts; Chassis Troubles and their Elimination; Fixing Tire Defects; Equipment and Accessories.

Handbook for Machine Designers and Draftsmen. By F. A. Halsey. 494 pages, 8½ by 11 inches. Illustrated. Published by the McGraw-Hill Book Co., Inc., New York City. Price $5 net.

This work by Mr. Halsey, editor emeritus of the "American Machinist," was under consideration by him for years. Mr. Halsey had fifteen years experience in machine design before he became an editor eighteen years ago. His practical work showed him the weaknesses of existing handbooks, and in his editorial experience he had seen many valuable articles contributed to the technical press go into the "limbo of forgotten things" with much regret. The present work was compiled largely from the files of the "American Machinist," but other publications and the transactions of engineering societies were drawn from freely also. This matter has been condensed and rearranged where necessary to make it harmonize with the general plan. The page size, 8½ by 11 inches, was chosen because of the growing popularity of the standard typewriter sheet size and the fact that the book is not in any sense a pocketbook, but is intended for use on the draftsman's and mechanical engineer's desk. The large size page favors the use of diagrams and charts, which have been freely used. The contents comprise the following chapters: Mechanical Principles of Design; Plain or Sliding Bearings; Ball and Roller Bearings; Shafts and Keys; Belts and Pulleys; Flywheels; Cone Pulleys and Back Gears; Spur Gears; Bevel Gears; Friction Gears; Worm Gears; Helical Gears; Planetary Gears; Ropes; Chains; Brakes; Friction Clutches; Cams; Springs; Bolts, Nuts and Screws; Wire and Sheet Metal Gages; Hydraulics and Hydraulic Machinery; Pipe and Pipe Joints; Minor Machine Parts; Press and Running Fits; Balancing Machine Parts; Miscellaneous Mechanisms; Performance and Power Requirements of Tools; Cast Iron; Steel; Alloys; Steam Boilers; The Steam Engine; The Gas Engine; Compressed Air; Mechanics; Strength of Machine Parts; Weights and Measures; Mathematical Tables. The author's plan is to constantly revise the work, keeping it up to date by introducing new articles and excluding old matter pertaining to obsolete practice.

NEW CATALOGUES AND CIRCULARS

Eugene Dietzgen Co., 218 E. 23rd St., New York City. Circular of the Dietzgen electric blueprinting machine.

Rockwood Sprinkler Co., Worcester, Mass. Circular of the Rockwood pressed steel union with bronze seats.

Terrell Equipment Co., Grand Rapids, Mich. Circular of steel lockers, wardrobes, cupboards, shelving, etc.

New Departure Mfg. Co. (Hartford Division), Hartford, Conn. Catalogue of "New Departure" ball bearing shaft hangers.

Fort Wayne Electric Works of General Electric Co., Fort Wayne Ind. Instruction Book 3056 on Type A Form A oil transformers.

Sprague Electric Works of General Electric Co., 527-531 West 34th St., New York City. Bulletin 247 on round type direct-current motors.

Rich Tool Co., Chicago, Ill. Catalogue No. 15 of high-speed twist drills, reamers, track bits, flat drills, bonding drills, drill chucks, reamer chucks and rivet sets.

W. S. Rockwell Co., 50 Church St., New York City. Catalogue No. 20 of Rockwell furnaces, illustrating a large variety of furnaces adapted to all classes of service.

Betts Machine Co., Wilmington, Del. Catalogue of standard metal planing machines ranging in size from 36 by 36 inches to 150 by 144 inches, frog and switch planers, accessories, etc.

Wiley & Russell Mfg. Co., Greenfield, Mass. Pamphlet entitled "The Tale of the Lightning Tap" describing features of tap construction of interest to users of screw threading tools.

Mesta Machine Co., Pittsburg, Pa. Bulletin K of gears and rolling mill pinions, machine molded. A chart is included for determining the safe loads for molded gears and pinions of cast steel.

Putnam Machine Co., Fitchburg, Mass. (Manning, Maxwell & Moore, Inc., New York City, general sales agents.) Circular of the Putnam heavy pattern 42-inch coach and truck wheel lathe.

Fort Wayne Electric Works of General Electric Co., Fort Wayne, Ind. Bulletins 1145 on Type ML three-bearing belted direct-current generators with balance wheels, and 1147 on Fort Wayne transformers, Type A.

Kales-Haskel Co., Detroit, Mich. Circular of special washers, pipe and wire clips, card holders, ratchet sectors, liners and shims, windshield hinge disks, screw machine products, etc., chiefly for automobile manufacturers.

Corbin Cabinet Lock Co., New Britain, Conn. Circular of the Corbin safety guard for presses and drops, providing an absolute preventative of injury to workmen without interfering with freedom of movement or the usual motion of hands and arms.

Herman Bacharach, 14 Wood St., Pittsburg, Pa. Pamphlet describing the Maihak indicator with Bottscher's power counter. This apparatus renders it possible to ascertain instantaneously the mean indicated horsepower of steam and gas engines.

American Tool Works Co., Cincinnati, Ohio. Circular of the "American" radial drilling machine built in 2, 2½, 3, 3½, 4, 5, 6 and 7-foot sizes, plain; 5, 6 and 7-foot sizes, full universal. The circular also contains data on drilling performed by the various sizes of the drills.

Ingersoll-Rand Co., 11 Broadway, New York City. Bulletin No. 8107 on "Little David" pneumatic drills. This machine is of the piston type, having four single-acting pistons connected to a crankshaft by connecting-rods. The connecting-rods are fitted with Hyatt roller bearings.

Wheelock, Lovejoy & Co., 23 Cliff St., New York City. Catalogue of "Blue Chip" high-speed steel and high-grade tool steels made by the Firth-Sterling Steel Co., McKeesport, Pa. The catalogue contains valuable information for all steel users, with illustrations of hardening room equipment, etc.

National Tube Co., Frick Bldg., Pittsburg, Pa. Safety calendar for 1913-14 illustrating in color a safety principle to be observed when crossing railroad tracks. Each page of the calendar bears a safety motto useful to superintendent, foreman and workman in shops, mills and factories. The motto of the calendar is "Safety Always."

Wells Bros. Co., Greenfield, Mass. Catalogue of the Wells self-opening threading dies, made in eight sizes ranging from ¼ inch to 3 inches capacity inclusive. The proper shapes of thread chasers for various metals are shown, and the construction details, making a catalogue of unusual interest to users of thread-cutting tools.

Joseph Dixon Crucible Co., Jersey City, N. J. Free to engineers, a limited number of booklets dealing with steam traps, unions for steam pipes, feeding graphite for lubricating purposes, etc. The booklets are treatises prepared by the well-known writer, W. H. Wakeman, who has contributed many articles on power engineering to the technical press.

Dodge Mfg. Co., Mishawaka, Ind. Catalogue 106A-14 of power transmission machinery, furnishing in condensed form information and price list of standard appliances embraced in the Dodge line. This condensed catalogue is offered as a more convenient form for ordinary uses than the company's complete catalogue containing about 600 pages.

McCrosky Reamer Co., Meadville, Pa. Catalogue of adjustable reamers, "Wizard" quick change chucks and collets, "Wizard" variable speed and reversing attachment for drilling machines, McCrosky expanding mandrels, "Searchlight" universal lamp brackets, "Nevastop" combination faceplate and dogs for facilitating rapid lathe work, etc.

Wanderer Works, Schoenau near Chemnitz, Germany. Catalogue of "Wanderer" milling machines of the knee, vertical spindle and planer types; automatic gear cutting machines; tool grinding machines; automatic dividing and engraving machines; tool accessories, etc. The catalogue is printed in English and illustrates a variety of interesting machine tools.

Ingersoll-Rand Co., 11 Broadway, N. Y. Pamphlet on steam, belt-driven and electric motor-driven air compressors Type 10. The pamphlet is unique in its typographical makeup, the text being a reproduction of typewriting with "thumb-nail"